Project #93.4.10

NORTHERN SEABROOK BEACH

COASTAL BEACH STUDY

- CIVIL
- MARINE
- PLANNING
- STRUCTURAL
- TRANSPORTATION

Appledore Engineering, Inc.

NORTHERN
SEABROOK BEACH

COASTAL BEACH STUDY

June 1995

Prepared For:

Town of Seabrook
99 Lafayette Road
PO Box 456
Seabrook, New Hampshire 03870

Prepared By:

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(816-003.DOC)

I. BACKGROUND

Purpose

The purpose of this study is to analyze existing beach conditions on the northern section of Seabrook Beach and evaluate options which would enhance the beach and improve shore protection for the existing residential development. To accomplish the analysis of existing conditions, AEI completed the following:

- Review of Archival Data
- Discussions with State and Local Officials
- Topographic Survey
- Littoral Material Sampling and Grain Size Analysis.

Our evaluation of options included:

- Site Inspection of several local shore protection structures
- Computer modeling of several options
- Qualitative evaluation of the effectiveness of the options to achieve enhancement of the beach and additional protection for the existing shorefront homes.

Study Area

Seabrook Beach forms part of the barrier beach system which extends from Plum Island to Great Boars Head. The barrier beach is backed by an extensive salt marsh system, the Blackwater River and portions of Hampton Harbor. The barrier beach has been heavily developed, with, primarily, residential development on the ocean side and commercial/residential development on the landward side. Route 1-A runs along the length of the barrier beach (see Figure 1 - Vicinity Map).

The study area for this report includes Seabrook Beach from Hooksett Street on the south to the Hampton Harbor inlet on the north (see Figure 2 - Existing Conditions Plan). The study area includes sections located within both the Town of Seabrook and the Town of Hampton.

Immediately south of the study area, the residential development is set back approximately 200 to 400 feet from the high tide line, allowing a dune system to exist between the high tide line and the development. This dune system was recently restored by the Town of Seabrook during the springs of 1993 and 1994 (IEP, Inc., 1988). Within the study area, the residential development occurs between 50 feet and 120 feet of the high tide line (see Figure 3). No continuous dune system exists within the study area, although several small dune systems and beach grass patches are evident.

The Hampton Harbor inlet is stabilized by jetties on both the north and south shores. The inlet provides boating access into and out of Hampton Harbor.
Shore protection structures in the study area consist of various measures constructed by individual property owners. Structures include concrete seawalls, stone revetments (armored slopes), and small dunes, among others. No continuous shore protection structure (either natural or man-made) is in place.

The location of the residential development with respect to the high tide line provides limited usable recreational beach width. Due to the lack of dune system development and proximity of houses to the high tide line, the study area is susceptible to damage during storm events. The houses and other shorefront structures also act to trap wind blown sand causing inconvenience and flooding concerns for the shorefront property owners.

One landmark within the study area is the exposed ledge located near mean low water, between Concord and Franklin Streets. Both the US Geologic Survey (USGS) maps and National Oceanic and Atmospheric Administration (NOAA) charts for the area refer to this exposed ledge as "Thomas Rock." However, the US Army Corps of Engineers plans and reports refer to this ledge as "Thompson Rock". Both Thomas and Thompson Rock are used interchangeably throughout this study to designate the ledge.

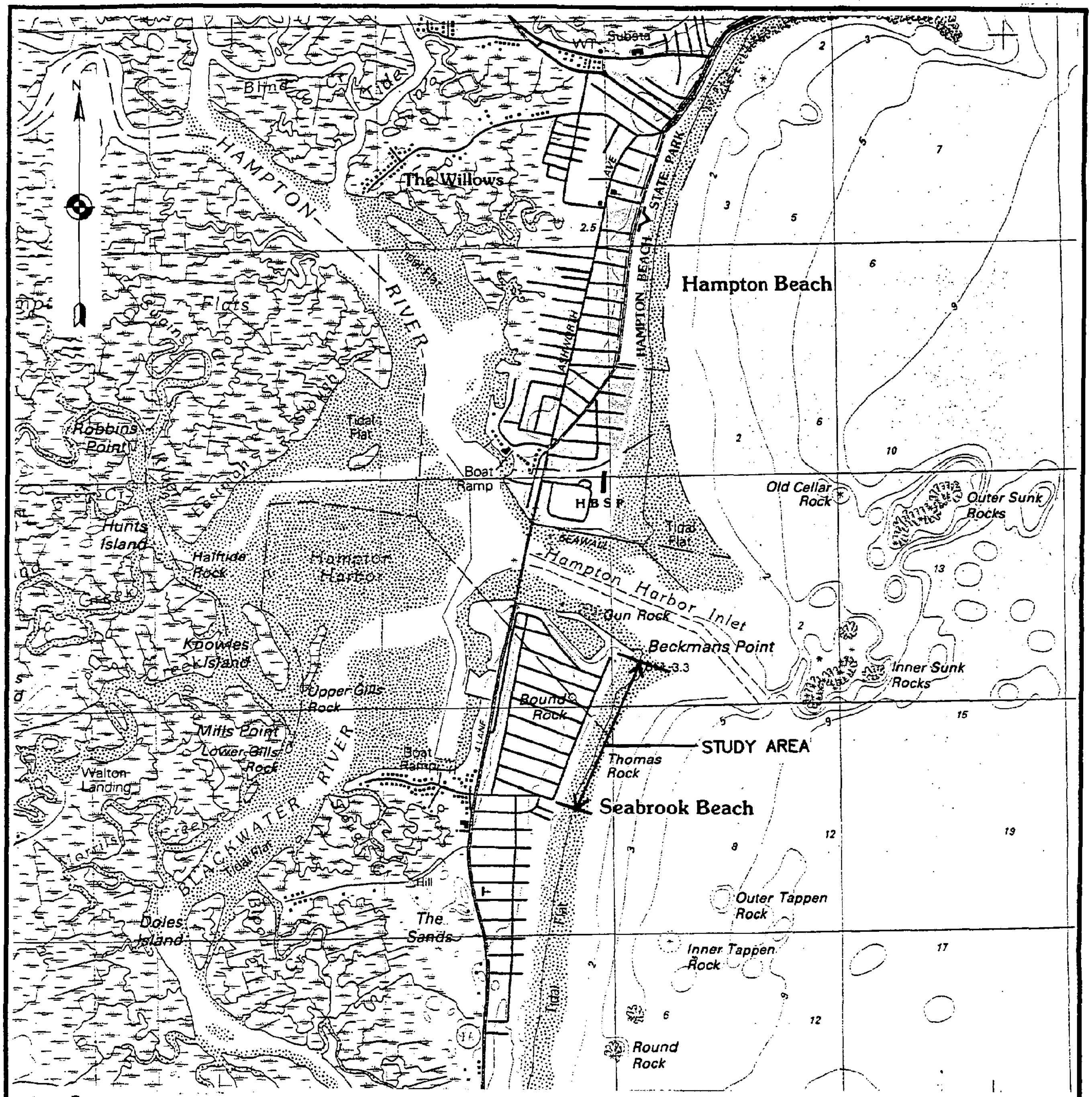
Vertical Datum

The vertical datum for this report is mean low water (MLW) based on the 1960 to 1978 tidal epoch. Reports from as far back as 1932 were reviewed for this study. Therefore, some reports reviewed were based on the 1941 to 1959 tidal epoch and others on the 1924 to 1942 tidal epoch. The 1932 report was most likely based on a mean low water datum with reference to the National Geodedic Vertical Datum of 1929. Additional shoreline information dates back to the late 1700's, when tidal data is relatively scarce.

Over the time period 1929 to 1995 there has been a relative rise in sea level of approximately 0.36 feet for the study area (NOAA, 1988). This study has not attempted to adjust data presented from previous reports for this relative rise in sea level.

Most published reports predict a continued relative rise in sea level, some suggesting an increase in the rate of sea level rise (Titus, 1987). Fixed structures, such as the existing seawalls and homes adjacent to the study area, would be subject to increased storm damage as sea level rises. Higher water levels would allow for larger waves to break closer to the existing structures. Natural barrier beach systems tend to retreat shoreward during periods of rising sea level (Dolan and Lins, 1987). Developed barrier beaches, as is the case with the study area, are not allowed to move shoreward without the displacement of existing buildings and structures.

Vertical control was established for the beach surveys completed by Appledore Engineering, Inc. (AEI) based on the USC&GS survey disk "Entrance" located adjacent to the study area (see Figure 2). The elevation of this disk is 15.37 feet based on the 1960 to 1978 tidal epoch, mean low water datum (AEI, 1992).



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Civil
Marine
Planning
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REFERENCE:
USGS QUAD, EXETER-NH 1:25,000

DATE: JUNE 1995

VICINITY MAP

0 1,042 2,083 4167

(IN FEET)

NORTHERN SEABROOK BEACH COASTAL BEACH STUDY

SEABROOK & HAMPTON
NEW HAMPSHIRE

FIGURE 1

(816VIC)

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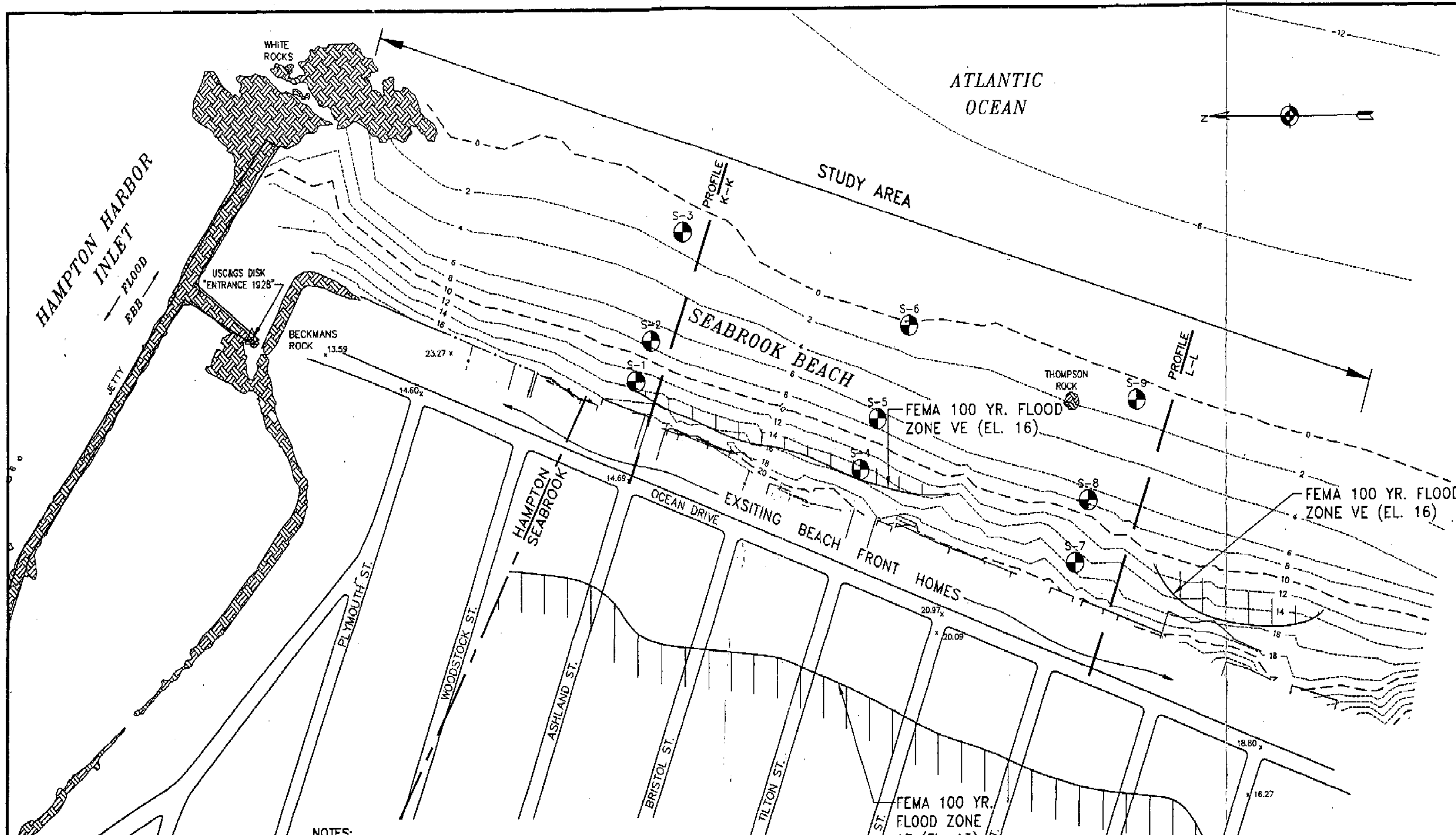

NOTES:

1. DEPTHS ARE IN FEET AND ARE REFERENCED TO MEAN LOW WATER (1969 TO 1978 TIDAL EPOCH).
2. CONTOURS WERE DEVELOPED FROM A SURVEY COMPLETED ON FEBRUARY 23, 1995 BY DOUCET SURVEY INC. THE SURVEY CAN ONLY BE CONSIDERED AS INDICATING THE CONDITIONS EXISTING AT THAT TIME AT THE LOCATION COVERED ONLY. CONTOURS WERE COMPUTER GENERATED USING AdCADD DTM VERSION 12.06, OPERATING WITHIN AUTODESK, AUTOCADD VERSION 12 (–6 AND –12 CONTOURS DIGITIZED FROM NOAA, 1990.)
3. VERTICAL BENCHMARK
   DESIGNATION: "ENTRANCE – 1928"
   STAMPING: ENT – 1928
   MONUMENTATION: SURVEY DISK
   AGENCY/DISK TYPE: USACE & GS TIDAL BENCH MARK
   SETTING CLASSIFICATION: STONE
   ELEVATION IN FEET ABOVE MLW (1960–1978 EPOCH): 15.37
   THE BENCH MARK IS SET IN THE SOUTH END OF A 15.0 FOOT WIDE SEAWALL, LOCATED 150 FEET NORTH FROM THE END OF OCEAN DRIVE, 33.0 FEET NORTH, FROM THE EDGE OF THE ROCK SLOPE TO THE BEACH, 385 FEET WEST FROM A 20 FOOT HIGH HARBOR MARKER 7A.
4. FEMA FLOOD ZONES, REFERENCE: FEMA, 1986

TIDAL DATA:	MLW DATUM
ESTIMATED 100 YR FLOOD (WITH WAVES)	16.0'
ESTIMATED 100 YR FLOOD (STILLWATER)	13.0'
HIGH TIDE LINE (H.T.L.)	11.0±'
MEAN HIGH WATER (M.H.W.)	8.3'
MEAN LOW WATER (M.L.W.) (1960 – 1978 TIDAL EPOCH)	0.0'
MEAN LOWER LOW WATER (M.L.L.W.)	-0.3'
ESTIMATED ANNUAL LOW WATER (A.L.W.)	-2.0±'
ESTIMATED EXTREME LOW WATER (E.L.W.)	-3.5±'

GRAPHIC SCALE
100 0 50 100 200 400
(IN FEET)

LEGEND:
S–8 APPROXIMATE BEACH MATERIAL SAMPLE LOCATION MAY 4, 1995
X SPOT GRADE

EXISTING CONDITIONS PLAN

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DATE: JUNE 9, 1995
SCALE: AS SHOWN
DESIGNED BY: JFM
DRAWN BY: NJE
APPROVED BY: RMS
PROJECT NO: 815
FILE NO: 815S

NORTHERN SEABROOK BEACH
COASTAL BEACH STUDY
SEABROOK & HAMPTON
NEW HAMPSHIRE

Civil
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FIGURE 2

REFERENCE:
JAMES W. SEWALL 1986

APPROXIMATE GRAPHIC SCALE
0 250 500 1000
(IN FEET)

AERIAL PHOTOGRAPH MARCH 1986

FIGURE 3

AEI Civil / Marine / Planning / Structural / Transportation Appledore Engineering, Inc. 600 State Street, Suite D Portsmouth, New Hampshire 03801 (603) 433-8818	*NORTHERN SEABROOK BEACH* *COASTAL BEACH STUDY* SEABROOK & HAMPTON NEW HAMPSHIRE	DATE: JUNE 9, 1995 SCALE: AS SHOWN DESIGNED BY: JFM DRAWN BY: NJE APPROVED BY: RMS PROJECT NO: 816 FILE NO: 816S	THIS FIGURE WAS FUNDED IN PART BY A GRANT FROM THE OFFICE OF STATE PLANNING, NEW HAMPSHIRE COASTAL PROGRAM, AS AUTHORIZED BY THE NATIONAL OCEANIC AND ATMOSPHERIC ADMINISTRATION (NOAA) GRANT AWARD NUMBER NA370Z0277

II. ANALYSIS OF EXISTING CONDITIONS

Review of Archival Data

The review of archival data included a review of reports and design memorandum from the US Army Corps of Engineers (USACE). A complete list of references is presented in Section V, Bibliography.

Prior to 1934/1935, when the Hampton Harbor inlet was stabilized, the harbor inlet migrated considerably (see Figure 4). At times the study area has been located in the middle of the inlet, to the north of the inlet or to the south, as it is at present. The inlet stabilization was undertaken to prevent the further northward migration of the inlet into the developed section of Hampton Beach (USACE, 1932). In the 1932 USACE Cooperative Study on Hampton Beach (USACE, 1932), it was noted that the installation of the jetty on the southern side of the channel was not for beach protection, but was for stabilization of the inlet. Two reference beach profiles (K-K and L-L) were located within the study area as part of the 1932 study (see Figure 2).

Several studies/reports were completed for Seabrook Beach following the stabilization of the Harbor inlet. A study completed in 1942 found no need for protection of Seabrook Beach (USACE, 1953).

A report completed in 1953 (USACE, 1953) summarized changes in the study area as follows:

Location	Dates	Elevation	Beach Change
Channel Entrance to Profile L-L	1931-1939	High water	170' accretion
Channel Entrance to Profile L-L	1931-1939	Low water	225' accretion
Channel Entrance to Profile L-L	1939-1940	High water	170' erosion
Channel Entrance to Profile L-L	1939-1940	Low water	100' erosion
Profile K-K	1940-1952	Above high water	30' erosion
Profile K-K	1940-1952	Between low and high water	accretion
Profile L-L	1940-1952	Above high water	erosion
Profile L-L	1940-1952	Between low and high water	erosion

Note: see Figure 2 for location of profiles.

This report also noted that while "The predominant direction of littoral drift along the region from Great Boars Head to Castle Neck is from north to south..... In general, there is no great predominance of drift in any one direction along this coastal region. Variations in drift probably occur depending upon the direction of approach of on-shore winds and waves which they generate". Strong tidal currents in the vicinity of the harbor inlet were also noted to transport littoral materials especially north of Thompson Rock. The 1953 report noted that sand from the northern portion of the study area may be moving northward over the breakwater and into the channel. This report, however, did not recommend any improvements for Seabrook Beach.

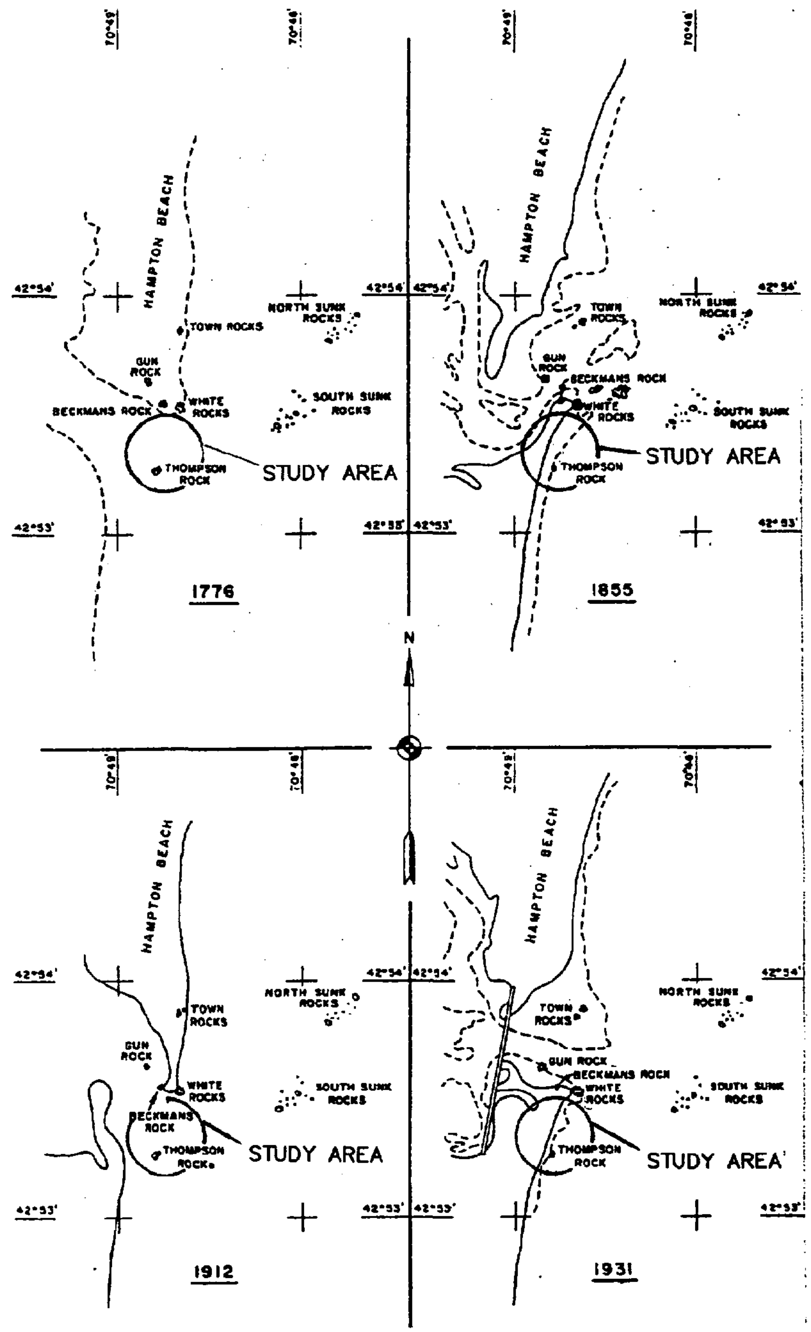
The beach front homes in the study area appear to have been constructed in the mid to late 1940's. An aerial photograph of the study area taken between 1932 and 1936 shows that residential development had not yet taken place (USACE, 1932). Plans from the USACE do not show the development in 1942, but do in 1953 (USACE, 1953). One beach front resident indicated that her home was built in 1947 (Manzi, 1955).

A report completed in 1962 (USACE, 1962) found general accretion in the study area between 1953 and 1959, with movement of the high water line 25 to 50 feet seaward, and up to 100 feet seaward movement near the northern end of the study area. The report noted "Since stabilization of the inlet, Seabrook Beach has alternated between erosion and accretion, the net effect of these changes resulting generally in only small shore line movements". This report also noted that the movement of littoral material in the study area is most predominantly on and off shore (east/west) not north/south along the beach. Movement of littoral material was also attributed to tidal currents that carried sand over the jetty, into and out of the harbor.

Location of the shorefront homes within the study area was also discussed in the 1962 report. The report noted that the homes are located about 75 to 90 feet landward of the high water line, and that seawalls and other shore protection structures have been built to prevent damage to the homes by storm wave attack. Frequent maintenance and construction activities were associated with the upkeep of these structures. Figure 5A shows a section of Seabrook beach in 1958 and a similar photograph from 1995 is shown in Figure 5C.

The 1962 report made two (2) recommendations for Seabrook Beach: first, enlarge a portion of the existing south jetty to prevent sand from moving north along the beach and into the channel and second, provide protection for the homes by constructing a protective sand beach of sufficient width to dissipate storm wave energy.

In 1963, the USACE recommended and implemented navigation improvements to the Hampton Harbor inlet. Recommended improvements included a 1,000 foot extension of the north jetty, and raising the outermost 300 foot section of the south jetty and providing a 180 foot spur to the south. The channel was also to be dredged to eight (8) feet at mean low water. The USACE issued a detailed project report (USACE, 1963) outlining the proposed work.



NOTE:
Shore line of 1776 from British Admiralty charts. Other shore lines from U.S.C. & G.S. charts, U.S.E.D. maps and maps of N.H. State Highway Department.
Traced from enlargement of Plate I of Beach Erosion Board's report dated July 15, 1932.

LEGEND
H.W. SHORELINE ——
L.W. SHORELINE - - - -

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REFERENCE:
USACE, 1953

DATE: JUNE 1995

HAMPTON HARBOR INLET
SHORE LINE CHANGES
1776–1931

APPROXIMATE
GRAPHIC SCALE
0 2,500 5,000 10,000
(IN FEET)

NORTHERN SEABROOK BEACH
COASTAL BEACH STUDY
SEABROOK & HAMPTON
NEW HAMPSHIRE

FIGURE 4

(816VIC)

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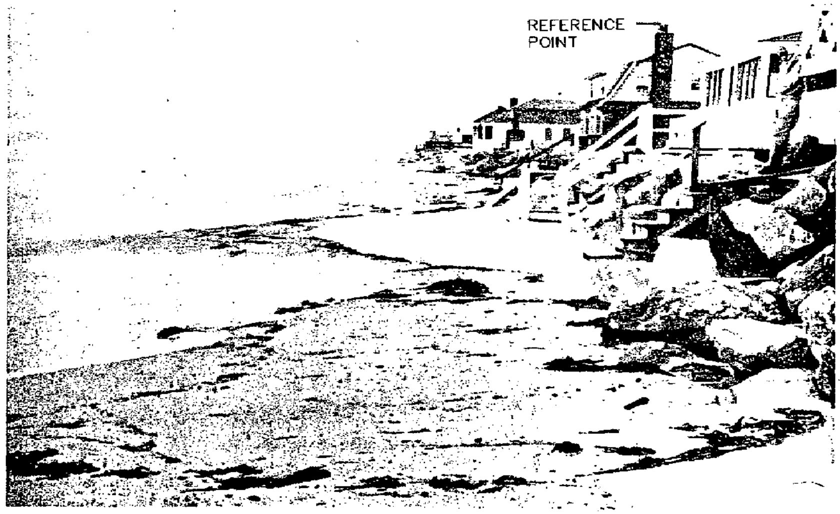

FIGURE 5A:
SEABROOK BEACH, SEPTEMBER 19, 1958.
REFERENCE: USACE, 1962

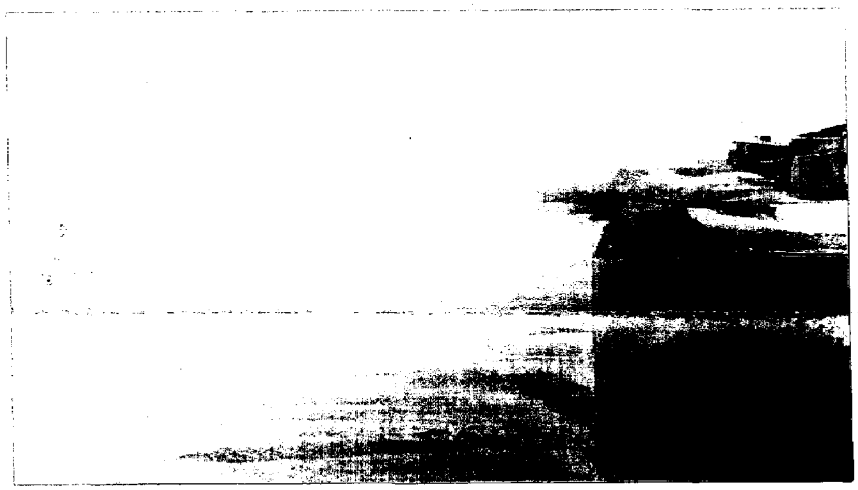

FIGURE 5B:
SEABROOK BEACH, FEBRUARY 6 OR 7, 1978.
REFERENCE: MANSI, 1995

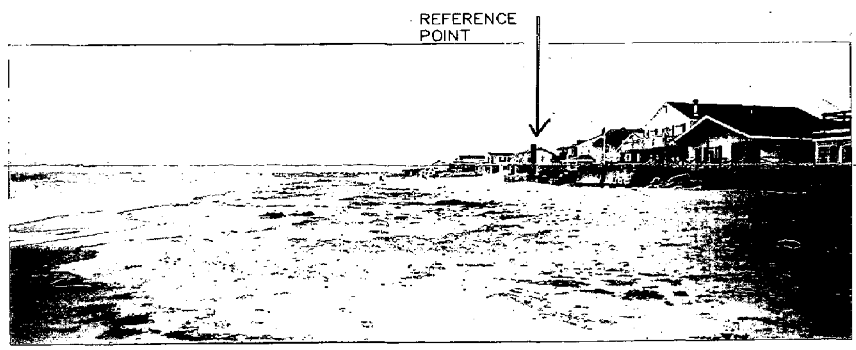

FIGURE 5C:
SEABROOK BEACH, MAY 12, 1995.

FIGURE 5	AEI Civil Marine Planning Structural Transportation Appledore Engineering, Inc. 600 State Street, Suite D Portsmouth, New Hampshire 03801 (603) 433-8818	**NORTHERN SEABROOK BEACH COASTAL BEACH STUDY** SEABROOK & HAMPTON NEW HAMPSHIRE	DATE: JUNE 9, 1995 SCALE: N.T.S. DESIGNED BY: JFM DRAWN BY: HJE APPROVED BY: RMS PROJECT NO: 816 FILE NO: 816S

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The 1963 detailed project report noted that construction of the north jetty extension would not be expected to reduce the supply of sand available for Seabrook Beach, but recommended that Seabrook Beach be monitored for shoreline recession and nourishment provided as necessary. As a condition for participating in the navigation improvements, the USACE required that "local interests" accept responsibility to "provide such beach nourishment at Seabrook Beach as may be required to off set a possible reduction in supply because of inlet improvement".

Other reports from the USACE indicate that material from Hampton Harbor was dredged and utilized for beach nourishment on Hampton Beach periodically including 1935, 1941, 1954, 1965, 1973, 1980, 1987 and 1993. The Hampton Beach nourishment project was authorized as a federal beach erosion control project in 1954. The Hampton Harbor entrance channel has been subject to more frequent dredging efforts including 1941, 1955, 1965, 1968, 1970, 1971, 1973, 1981 and 1984.

A report compiled by the Strafford Rockingham Regional Council (1978) detailing the effects from the Blizzard of 1978 did not indicate any long term changes in the study area as a result of the storm. Some steepening of the beach profile and an increase in the off-shore sand bar was noted after the storm. However, summer wave conditions returned much of the sand to the beach. It was further noted that the riprap revetments and seawalls along the northern portion of the beach were found to be insufficient for a storm of this magnitude. A photograph of the study area taken during the blizzard of 1978 is shown on Figure 5B.

The 1982 Final Environmental Impact Statement for the New Hampshire Coastal Program Ocean and Harbor Segment (NOAA 1982) did not list Seabrook Beach as an area of significant erosion, but did list the Seabrook Dunes as an area requiring stabilization.

The Rockingham Planning Commission's 1986 update to "Assessment, Impact and Control of Shoreline Change Along the New Hampshire's Tidal Shoreline" noted that periodic erosion at Seabrook Beach is not critical but does have the potential to impact the homes located along the northern portion of the beach. This report did not recommend improvements along the northern portion of the beach but did suggest restoration of the dune system along the southern portion of the beach (as previously noted, the Seabrook dunes underwent a restoration effort in 1993 and 1994). An on-going monitoring program for all New Hampshire coastal areas was also recommended.

Review of data available from NOAA did not reveal any damage from Hurricane Bob in August, 1991 (NOAA, 1991) for Seabrook Beach. However the destruction of one house on Seabrook Beach during the "Halloween Storm", October 1991 was reported (NOAA, 1992).

Aerial Photographs of the study area were reviewed along with historic maps. This data is summarized on Figure 6, Historic High Water Schematic Plan. Data from previous USACE and recent AEI beach surveys was used to generate the historic beach profiles shown in Figure 7. The high-water lines and profiles show significant variation from year to year, but a long term pattern of erosion or accretion is not evident.

Discussions with State and Local Officials

On May 11, 1995 a meeting was held with Dr. Frank Richardson, of the New Hampshire Wetlands Board (NHWB) at the offices of the New Hampshire Coastal Program in Portsmouth. Existing conditions and possible improvements to Seabrook Beach were discussed. According to Dr. Richardson, the homes situated along the study area were built by flattening the dune area of the beach. This construction took place prior to the 1970's implementation of NHWB regulations concerning activities in dune areas. He felt that the area between the houses and high water line has been accretional and the system is trying to naturally rebuild the dunes. He noted that the installation of snow fences in this area will typically capture a substantial amount of sand. The build up of sand in front of seawalls and riprap causes storm waves to run up the sand slopes and overtop the seawalls causing concern among the homeowners. The Hampton portion of Seabrook Beach received some beach nourishment in 1993 following the dredging of Hampton Harbor. Dr. Richardson indicated that one solution may be to allow relocation of the sand which accumulates in front of the walls on an annual basis. Dr. Richardson expressed support for improvements which would encourage establishment of a dune system in the study area and he would also support nourishment of the beach.

Discussions were also held with Mr. Robert Moore, Seabrook Code Enforcement Officer and Mr. E. Russell Bailey, Seabrook Town Manager on January 6, 1995. They noted that the Town has concerns with erosion of Seabrook Beach causing a loss of usable beach area and increasing the susceptibility of the beach front homes to storm damage. They also noted that beachfront property owners have moved sand from in front of seawalls in the past and continue to request permits to do so. It was their understanding that the sand build-up allows storm waves to run-up and overtop the seawalls causing problems for the beach front property owners. They were also concerned that if dunes were allowed to develop, there would not be sufficient area for beach users. It was noted that the Town has represented that it owns the beach from the seawalls to low water.

Topographic Survey

A topographic survey of the study area was completed on February 23, 1995, from the existing seawalls down to approximately low water. The results of the topographic survey data is shown on the Existing Conditions Plan (Figure 2). The data collected was also compared to a previous beach survey completed by AEI in January 1992, and with historic high water line data (See Figure 6). The 1992 AEI survey covered the northern 1,500± foot section of the study area. This portion of the beach experienced a net accretion of approximately 8,000 cubic yards between January 1992 and February 1995. The 1992 and 1995 survey data was also used in comparison with historic beach profiles taken at profiles K-K & L-L (See Figures 2 and 7). Variation between the profiles is obvious but no long term trends were noted.

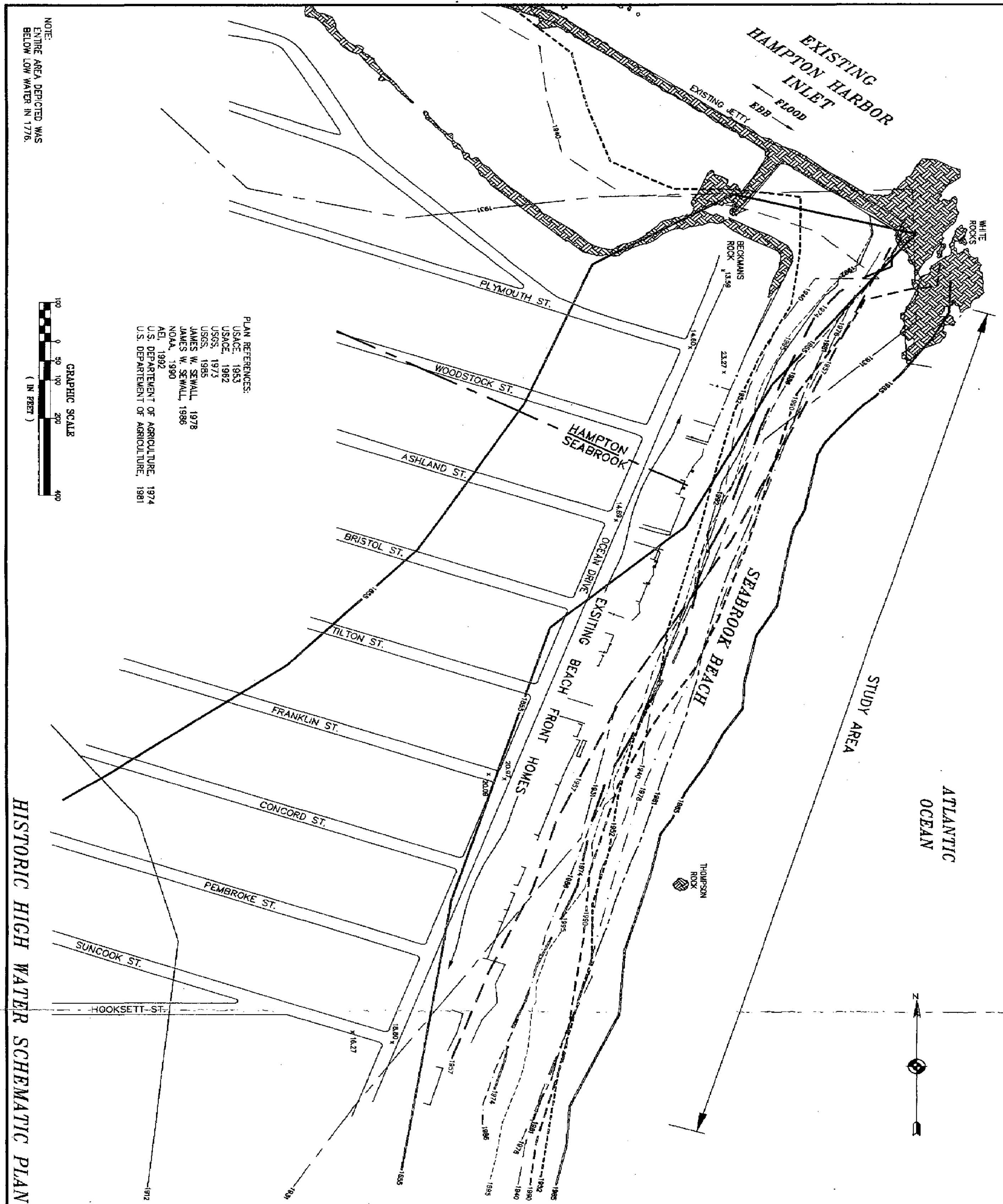

FIGURE 6	AEI Civil / Marine / Planning / Structural / Transportation Appledore Engineering, Inc. 600 State Street, Suite D Portsmouth, New Hampshire 03801 (603) 433-8818	*NORTHERN SEABROOK BEACH COASTAL BEACH STUDY* SEABROOK & HAMPTON NEW HAMPSHIRE	DATE: JUNE 9, 1995 SCALE: AS SHOWN DESIGNED BY: JFM DRAWN BY: NJE APPROVED BY: RMS PROJECT NO: 816 FILE NO: 816S	THIS FIGURE WAS FUNDED IN PART BY A GRANT FROM THE OFFICE OF STATE PLANNING, NEW HAMPSHIRE COASTAL PROGRAM, AS AUTHORIZED BY THE NATIONAL OCEANIC AND ATMOSPHERIC ADMINISTRATION (NOAA) GRANT AWARD NUMBER NA370Z0277

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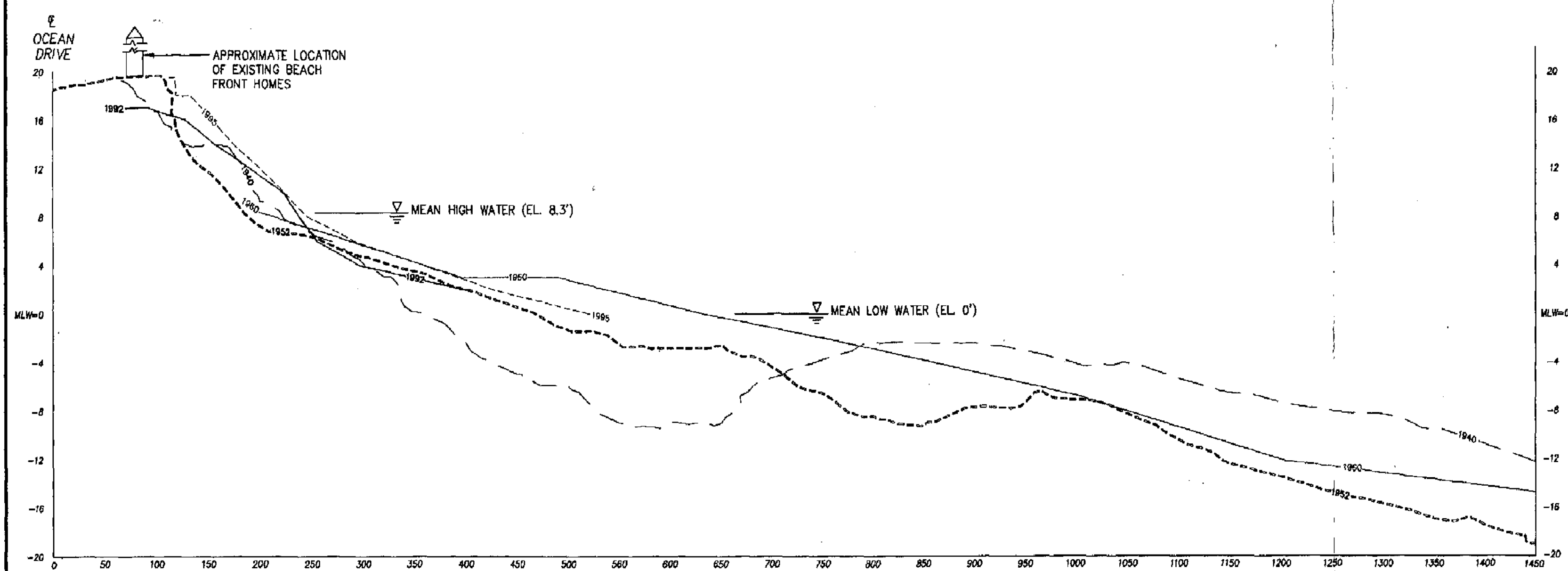
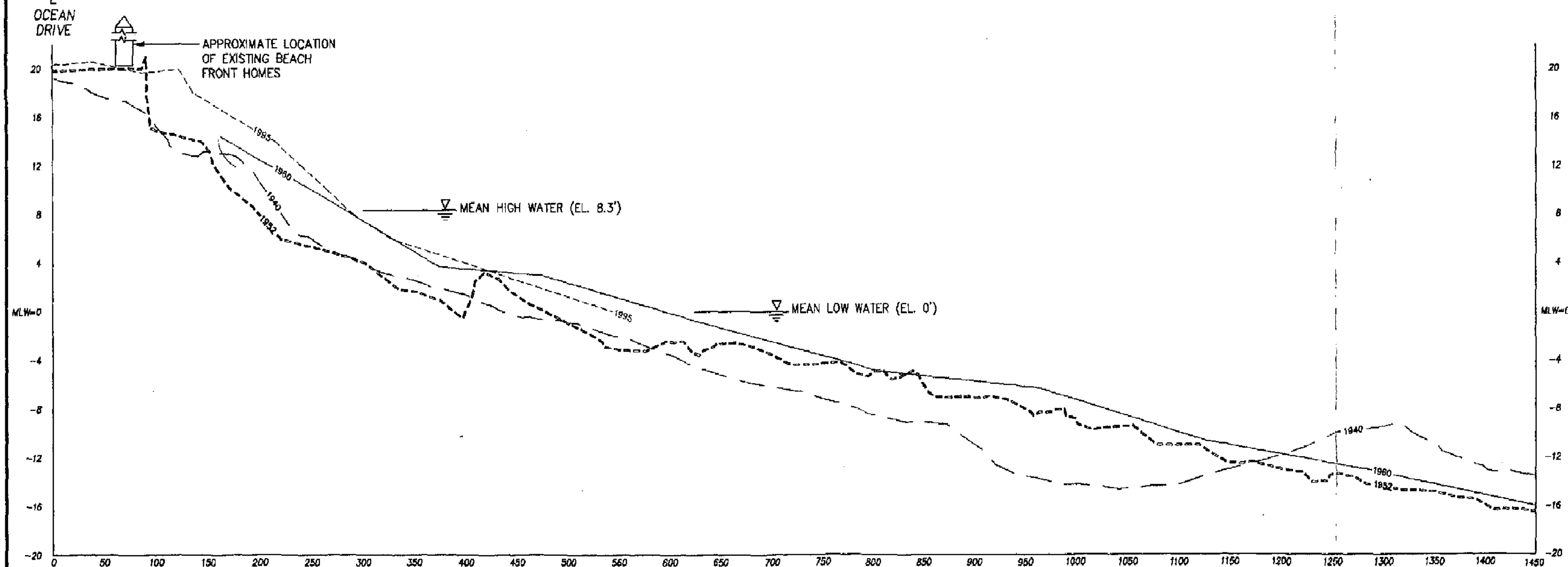


PROFILE K–K



PROFILE L–L

PLAN REFERENCES:
USACE, 1953
USACE, 1962
AEI, 1992

NOTE:
1960,1952 & 1940 DATA NOT CORRECTED TO CURRENT TIDAL EPOCH DATUM

HORIZONTAL SCALE
50 0 25 50 100 200
(IN FEET)

VERTICAL SCALE
5 0 2.5 5 10 20
(IN FEET)

HISTORIC BEACH PROFILES

FIGURE 7

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NORTHERN SEABROOK BEACH
COASTAL BEACH STUDY
SEABROOK & HAMPTON
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SCALE: AS SHOWN
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Littoral Material Sampling and Grain Size Analysis

Nine (9) littoral material samples were collected on May 4, 1995. The approximate locations for these samples are shown on Figure 2. Grain size analyses were conducted on the nine (9) samples. The results of these analyses are presented in Appendix A. All samples were primarily uniform fine to medium sand. No trends in grain size were apparent either horizontally or vertically. The median grain size (D_{50}) of the samples varied from 0.31 mm to 0.50 mm.

The median grain size was compared to median grain size from beach samples collected in August, 1932 (USACE, 1953). The median grain sizes in 1932 varied from 0.241 to 0.305 (fine to medium sand). It is not known if this variation in grain size is seasonal or long term.

The beach median grain size was also compared to Hampton Harbor bottom material samples collected by AEI in 1992 for the Hampton Harbor Dredging Project. Median grain size for the 1992 samples varied from 0.14 mm to 0.65 mm, with over half of the samples having median grain seizes above 0.30 mm. Therefore, it appears that much of the bottom material in Hampton Harbor is fine to medium sand and would be suitable, with respect to grain size, for beach nourishment on Seabrook Beach.

Modeling

The software program "Wave Run-Up" developed by Stone & Webster (1981) was used to evaluate the existing wave runup characteristics on Seabrook Beach. This software package is the same as was used in the Flood Insurance Study (FIS) for Seabrook Beach Village District, New Hampshire (FEMA, 1986) and results compared favorably with the FIS.

Various storm events were considered, including tide levels of annual high water, 10-year high water and 100-year high water and waves from five (5) to thirty (30) feet. Run-up was examined at beach profiles L-L and K-K for conditions of both exposed seawalls and sand covered seawalls. Under some wave/tide conditions, the exposed seawalls did produce lower wave run-up values than the seawalls covered with sand. Wave conditions where the exposed walls produced lower run-up values tended to be the smaller, shorter period waves which would generally occur on a more frequent basis.

It should be noted that the seawalls examined are all located above the 100-year still water flood elevation. The FEMA flood map for the study area and the topographic survey completed for this study indicate that all homes located directly adjacent to the beach are above the 100-year flood elevation.

Analysis/Evaluation

Based on the data reviewed, the following observations regarding existing conditions on Seabrook Beach are noted:

- The beach front residences along the study area were built in an area that was and is subject to periodic attack from storm waves.

- The beach appears to have remained relatively stable following the 1934/1935 stabilization of Hampton Harbor inlet.

- Seasonal and year-to-year changes in beach profile and volume occur. Depending on the season and year, varying usable beach and protection for the shorefront residences is provided.

- Long term erosion or accretional trends, if present, are masked by the seasonal and year-to-year variations, based on a relatively short time period (1932 to present).

- Sand build up between the homes and the beach is to be expected on a barrier beach system. The homes and shore protection structures contribute to sand build up by locally reducing wind speed (similar to a snow fence).

- Modeling of wave run-up on the beach profile indicates that under some wave/storm conditions the build-up of sand in front of the existing seawalls does promote greater run-up than with the seawalls exposed. The modeling did not consider erosion of the sand in front of the walls during a storm event.

Conclusion

A long-term beach erosion problem has not been observed in the study area. Seasonal and year-to-year beach erosion reduces usable beach width. Beach front residences are located in an area which was and is subject to periodic storm water attack. Beach front residences are also located in an area prone to wind blown sand accumulation.

III. REVIEW OF OPTIONS FOR BEACH IMPROVEMENT

Inspection of Local Shore Protection Structures

On May 12, 1995 site inspections of various local shore protection structures were completed. The inspection was intended to make visual observations regarding the performance of each structure following the winter season. It should be noted that the 1994 - 1995 winter was relatively calm.

Plaice Cove, North Hampton, has similar shore protection measures as the study area. There is a relatively narrow beach, with riprap and seawalls protecting the waterfront homes. There does not appear to be much usable beach at high water. At the southern end of the cove, there appears to be a substantial elevation difference between the homes and the high water line. Although of different construction, the shore protection structures appear to provide a continual barrier along the entire cove. No damage from winter storms was noted.

North Beach, Hampton has a recurved concrete seawall, protecting Route 1-A. In front of the seawall, beach cobble provides toe protection for the seawall. It appears that there is no sand beach at high water. No winter storm damage was noted.

Hampton Beach (main beach) has a concrete seawall shore protection structure fronted by a broad sand beach. Beach width tapers to the North. This area has been nourished with sand dredged from Hampton Harbor several times in the past. No obvious damage from winter storms was noted.

Hampton Beach State Park, just north of the harbor entrance channel, has a dune system with a sand beach for shore protection. The beach was nourished with sand from the Hampton Harbor Dredging Project during 1993. Beach width is approximately 150' ± to the high tide line. The dunes show the remnants of a scarp, probably developed during the winter of 1993/1994. No winter storm damage from 1994/1995 was noted.

The recently restored Seabrook Dunes, south of the study area, appeared to be performing well. Sand appears to be continuing to build in the dune areas, and new stands of beach grass were observed. The shoreside face of the dunes developed a minor scarp from winter storms, a condition which would be expected to be naturally restored during the summer months.

Salisbury Beach recently installed a "sacrificial" dune to provide additional shore protection. The dune was created by importing sand from an upland off-site source (Magnifico, 1995). The dune appeared to be on the order of five (5±) feet high. Snow fence has been added to try and accumulate additional sand. The base of the dune was located at approximately the high tide line. According to State Beach personnel, the dune will be planted with beach grass in the future (Magnifico, 1995). Although the dune did not appear to have sustained damage from winter storms, it does appear vulnerable to wave attack.

Homes along Plum Island Beach are protected by a small dune system. Plum Island also possesses a series of approximately 200 foot long stone groins spaced approximately 0.25 miles apart which were constructed sometime before 1958 (Saniuk, 1995). Over the past ten (10) years, Plum Island has been experiencing beach accretion to a point where the stone groins are totally buried under the beach. This has not always been the case, in September 1972, tropical storm Carrie generated twenty five (25) foot ocean swells which, coupled with high tides, eroded eighteen (18+) vertical feet of beach and sand dune (Saniuk, 1995). Today more beach exists on the island than local residents can remember, providing ample room (300 feet +) for beach users. Small dunes have formed in front of many of the residences which are now vegetating with beach grass. The installation of snow fence has been attributed to increasing the height of the sand dunes in front of some residences (Saniuk, 1995) While the beach slope below high water was steep, no evidence of winter storm damage was observed.

Alternative Analysis

The following is a list of alternatives which were considered, in our evaluation of possible Seabrook beach enhancements:.

1. **No Action Alternative**:

The beach would continue seasonal and year to year erosion/accretion cycles. Sand would continue to accumulate in front of seawalls.

Evaluation:

During erosional periods the beach would not provide additional usable area for beach users or protection for the shorefront homes. The sand build up in front of the seawalls would continue to cause wave run-up concerns for home owners. There would be no initial construction costs. Continued maintenance and repair costs for homes and shore protection structures should be expected. Environmental impacts during severe storm events which destroy man-made structures can be expected.

2. **Movement of Sand From In-Front of Seawalls:**

Homeowners would be permitted to regrade sand from in front of existing seawalls on an annual or semi-annual basis.

Evaluation:

This alternative would not provide significant increased usable beach area nor provide significant additional protection for shorefront property owners under most storm conditions. It may reduce wave run-up for some wave and storm conditions. The removed sand could be used to create a small berm near the high water mark to provide some added shore protection. As long as the sand is not removed from the beach, this alternative should not have a significant long term effect on the beach. Annual maintenance costs would need to be assumed by the shore front property owners or the Town. Short term disturbance of the beach environment during sand removal activities should be expected. It may be possible to combine this alternative with other alternatives.

3. **Installation of "Snow" Fence:**

"Snow" fence would be installed between the high water line and the existing seawalls to encourage a build up of sand, without reducing the efficiency of the existing seawalls.

Evaluation:

This alternative would provide some additional short term, sacrificial protection for the shorefront property owners. It may also reduce the amount of sand building up immediately in front of the existing seawalls by "catching" the sand before it gets to the seawalls. There would most likely be a reduction in usable beach area if fence is in place during the summer. There would be minimal initial cost, but maintenance/replacement costs due to storm damage should be anticipated. No significant long term environmental impacts would be expected.

4. **"Sacrificial" Dune Construction:**

A relatively small, five (5±) foot sand berm would be constructed between the high water line and the existing seawalls. Sand would be "imported" to the beach from either off-site upland sources or from dredging projects. The berm could be planted with beach grass.

Evaluation:

This alternative would provide some additional short term, sacrificial protection for the shorefront property owners. There would not be an increase in usable beach area and there may be a reduction in beach area if the berm is planted with beach grass. This option would not address the build up of sand against the seawalls. Depending on the source of the sand, initial construction costs could be high and frequent maintenance costs would be expected. No significant long term environmental impact would be expected.

5. **Conventional Dune Construction**:

A conventional twenty (20±) foot high sand berm would be constructed between the high water line and the existing seawalls and planted with beach grass. Sand would be "imported" from either off-site upland sources or from dredging projects.

Evaluation:

There does not appear to be enough space between the high water line and the existing seawalls to establish a healthy, sustainable dune system. Therefore, this alternative is not considered practical by itself.

6. **Beach Nourishment**:

The beach would be widened to a minimum of 200 feet to the high tide line to provide a beach width similar to the portion of Seabrook Beach located immediately to the south of the study area (see Figure 8).

Evaluation:

This alternative would provide for both long term increased usable beach area and increased protection for the shorefront homes. By moving the high water line away from the existing seawalls the chance of having wave run-up over top the existing seawalls would be reduced.

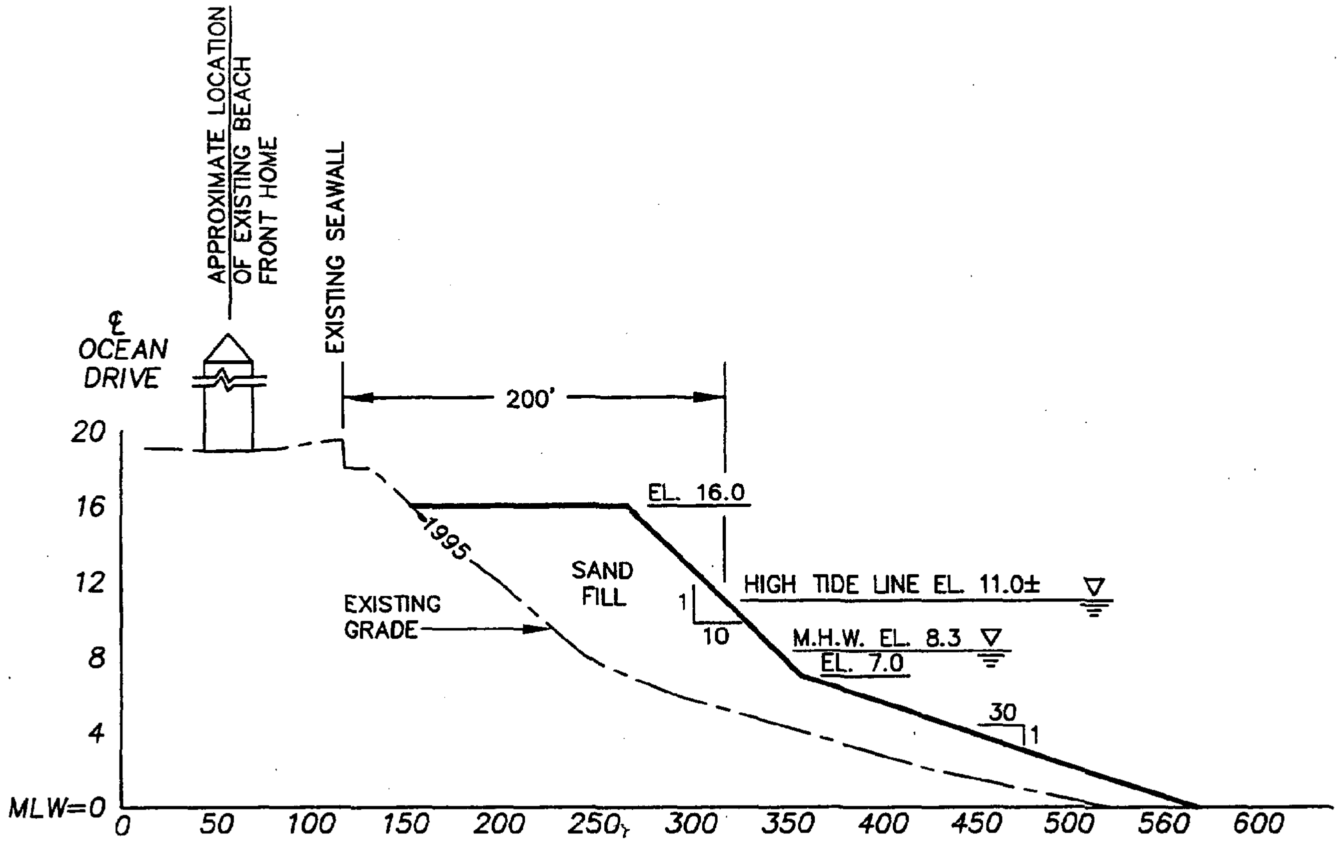
If sand is available from local maintenance dredging activities, the initial construction cost may be moderate. This alternative would be much less cost effective if sand were to be brought in from off-site upland sources. Recurring maintenance costs can be expected. Implementation of this alternative may also require construction of an extension to the southern Hampton Harbor inlet breakwater to prevent sand from rapidly migrating into the channel. No significant long term environmental impact would be expected.

7. **Beach Dewatering System**:

A drain line system would be installed under the beach and water pumped from the drain line back into the ocean. The system theoretically creates a dewatered section of beach which reduces wave back wash to the ocean and thereby traps additional sand on the beach, promoting accretion.

Evaluation:

A beach dewatering system may provide more usable beach and additional shore protection for the shorefront property owners. However, the technology is relatively new and unproven over the long term. This alternative relies on a mechanical system which would likely require high maintenance. Installation cost would be moderate. Some environmental concerns would need to be addressed.



BEACH PROFILE K–K

AEI Civil / Marine / Planning / Structural / Transportation

Appledore Engineering, Inc.
600 State Street, Suite D
Portsmouth, NH 03801 (603)433–8818

DATE: JUNE 1995

BEACH NOURISHMENT
TYPICAL FILL PROFILE

0 50 100 200

HORIZONTAL SCALE (IN FEET)

0 5 10 20

VERTICAL SCALE (IN FEET)

NORTHERN SEABROOK BEACH
COASTAL BEACH STUDY

SEABROOK & HAMPTON
NEW HAMPSHIRE

FIGURE 8

(816TYP.DWG)

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8. **Sand By-Passing System**:

A permanent or semi permanent dredge plant would be set up to pump sand from the Hampton side of the Hampton Harbor inlet to Seabrook Beach.

Evaluation:

This type of system is generally utilized when breakwaters or other shore protection structures interrupt the normal long shore transport of sand and cause significant accretion upgradient of the structure and erosion down gradient. As this accretion/erosion scenario does not appear to be a significant cause of the current concerns at Seabrook Beach, this option is not considered practical.

9. **Off-Shore Breakwater Construction**:

A rubble mound breakwater(s) would be constructed off shore and parallel to the beach.

Evaluation:

This alternative would reduce storm wave height on the beach and provide long term protection for the beach front homes. By reducing the wave environment, off shore breakwaters tend to reduce beach erosion. However, with the reported predominant movement of sand on-shore/off-shore, a breakwater(s) would need to be carefully analyzed to determine the impact on the present beach equilibrium. This alternative would have a high initial cost and significant environmental and navigational concerns would need to be addressed. The impact on beach width would need to be studied.

10. **Groin Construction**:

A series of groins (stone, timber or concrete walls) would be constructed perpendicular to the shore to trap sand.

Evaluation:

Groins are generally utilized where there is a significant long shore movement of sand. As this does not appear to be the case with the Seabrook Beach, this option is not considered practical.

11. **Continuous Seawall Construction**:

A continuous shore protection structure, either concrete seawall or riprap stone revetment, would be constructed on the entire length of the study area. All current shore protection structures would be replaced by this system.

Evaluation:

This alternative would not provide more usable beach area. It would provide better long term protection for the beach front residents than the current piecemeal shore protection structures. However, this alternative may have the same problem with sand build up as existing seawalls. Toe scour and wave reflection would need to be carefully considered in the design to prevent causing beach erosion problems. This alternative would have high initial construction costs and substantial environmental and liability concerns would need to be addressed.

12. **Elevating Existing Homes**:

The residences along the shoreside of Ocean Drive would be elevated on piles.

Evaluation:

This alternative would not provide significantly more usable beach area. Protection for the existing beach front homes would be improved, but unless additional shore protection is provided, Ocean Drive and homes shoreward of Ocean Drive may be subject to wave attack under storm wave conditions. This alternative would have a high initial cost and substantial social/political/economic concerns would need to be addressed.

13. **Removal of Existing Homes and Dune Restoration**:

The residences along the shoreside of Ocean Drive would be purchased (by the Town/State/Federal government) and removed. Dunes would be restored to the area either by encouraging sand accretion or importing sand.

Evaluation:

Under this alternative, there may be an increase in usable beach area (depending on the equilibrium state established by the dunes) and protection of the beach front homes would not be required. Homes located shoreward of Ocean Drive would be afforded the long-term protection of an established dune system. This alternative would have a very high initial cost and substantial social/ political/economic concerns would need to be addressed.

IV. RECOMMENDATIONS

The following are our recommendations for implementing improvements to Seabrook Beach. These are broken down into both short-term and long-term. Order of magnitude cost estimates are provided for each recommendation.

Preferred Short-Term Alternative

Establish annual regrading program to move sand away from existing seawalls and back onto the beach (Alternative 2). This will reduce run-up on the existing walls without reducing usable beach area or long-term shore protection. Install "snow" fence between the high water line and existing seawalls (Alternative 3). The snow fence will trap sand, creating/enhancing a small berm. This berm will provide short-term, sacrificial shore protection. This may also reduce sand build-up in front of existing seawalls. The snow fence could be positioned to minimize reduction in usable beach area. A study should be completed to determine optimal snow fence layout. The effectiveness of these Alternatives and the need to move sand from in front of the existing seawalls should be monitored on an on-going periodic basis (at least twice a year).

The typical design storm for this type of shore protection structure is a five (5) year storm event. This indicates a twenty (20) percent chance that the snow fence/berm would need to be replaced in any given year.

Engineers Preliminary Cost Estimate:

Layout Study, Permitting and Design Specifications:	$ 5,000.00
Snow Fence (Material and Installation) - 5,000 linear feet:	$ 12,500.00
Regrade Sand Away From Existing Seawalls (8,000 cy first year)	$ 20,000.00
Monitoring (first year)	$ 2,500.00
Estimated Total	**$ 40,000.00***

* Does not include annual maintenance or continued monitoring costs. Annual maintenance for Alternative 3 may be estimated as 20% of initial construction of this type of shore protection system.

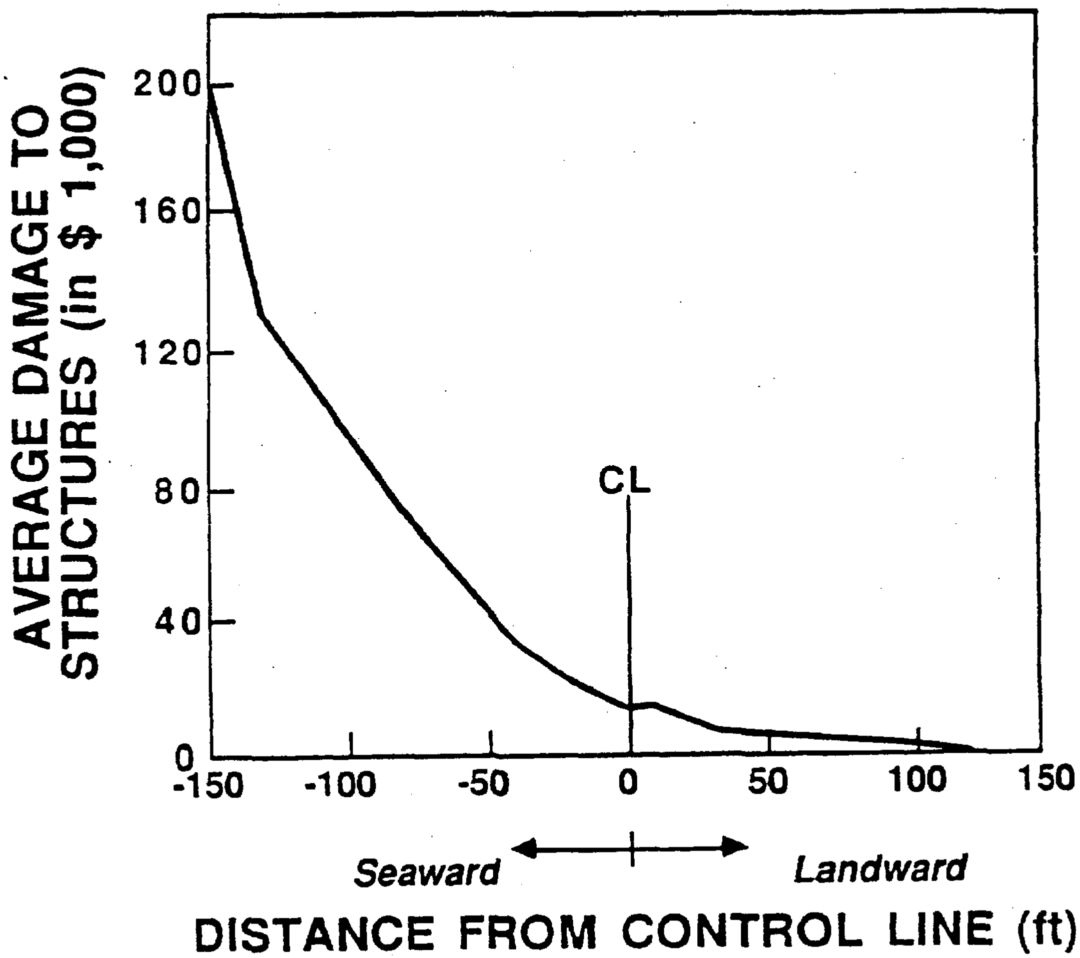
Preferred Long Term Alternative

Nourish beach with 100,000 cy of sand to provide a minimum of 200± feet of distance between the high water line and the existing seawall (see Figure 8). From an economic stand point, nourishment should be completed with fine and medium sand removed from Hampton Harbor or the Hampton Harbor inlet during maintenance dredging activities (both the harbor and inlet require frequent periodic maintenance dredging). In addition to providing additional usable beach area (from 50± feet to 200± feet at high water) the nourished beach would also provide additional long-term protection for the shorefront property owners assuming current beach erosional/accretional trends continue. As shown in Figure 9, the average storm damage cost to a structure is related to the location of the structure relative to the shore line (Dena and Wang, 1992). By adding width to the beach you can effectively increase a structures distance from the shore and reduce storm damage costs. This increased storm protection should lessen home owner concerns of wave run-up overtopping the existing seawalls due to sand build-up.

After beach nourishment takes place, consideration can be given to establishing a dune system on the widened portion of the beach. Either use of snow fence to catch sand or additional dredge material in conjunction with beach grass plantings could be used to encourage dune development.

A feasibility study should be completed to determine existing sand budgets for the area along with the proposed nourishment project and to determine the need for an extension of the south jetty. The annual maintenance cost for the nourished beach should also be estimated. Previous estimates from the USACE (USACE, 1963) indicated required maintenance of 4,000 cy per year. Semi-annual surveys of the beach should be completed to monitor the nourishment project.

The Town should contact the appropriate state and federal agencies responsible for dredging Hampton Harbor and the inlet to determine schedules for maintenance dredging and to indicate the desire to use the dredge material for nourishment of Seabrook Beach.



Damage to Structure in Relation to its Location with Control Line (Resulting From Study of 540 Structures in Bay County After Hurricane Eloise, by Shows, 1978).

AEI Civil Marine Planning Structural Transportation Appledore Engineering, Inc. 600 State Street, Suite D Portsmouth, NH 03801 (603)433-8818	DAMAGE TO STRUCTURES VERSUS LOCATION TO SHORE LINE	*NORTHERN SEABROOK BEACH COASTAL BEACH STUDY* SEABROOK & HAMPTON NEW HAMPSHIRE
REFERENCE: DEAN & WANG, 1992 DATE: JUNE 1995		*FIGURE 9*

(816VIC)

THIS FIGURE WAS FUNDED IN PART BY A GRANT FROM THE OFFICE OF STATE PLANNING, NEW HAMPSHIRE COASTAL PROGRAM, AS AUTHORIZED BY THE NATIONAL OCEANIC AND ATMOSPHERIC ADMINISTRATION (NOAA). GRANT AWARD NUMBER NA370Z0277.

Engineers Preliminary Cost Estimate:

	Without Dredging Costs*		With Dredging Costs**
Feasibility Study	$ 20,000.00		$ 25,000.00
Permitting	$ 10,000.00		$ 25,000.00
Placement and Grading of Sand on Beach - 100,000 cy	$ 300,000.00		$ 1,000,000.00
Estimated Subtotal	$ 330,000.00	to	$ 1,050,000.00
Dune Construction from Dredge Material - 150,000 cy (if needed)	$ 500,000.00		$ 1,300,000.00
200± feet Jetty Extension (if needed)	$ 500,000.00		$ 500,000.00
Final Engineering	10% of Construction Cost		10% of Construction Cost
Monitoring (first year)	$ 5,000.00		$ 5,000.00
Estimated Total	$ 1,470,000.00	to	$ 3,135,000.00***

* Assumes navigational dredging of the harbor or channel completed independently by the State or Federal Government.

** Assumes dredging completed only to obtain material for beach nourishment.

*** Does not include annual maintenance or monitoring costs.

Recommended Plan of Action

1. Implement preferred short term alternative.

2. Determine schedule for maintenance dredging activities in Hampton Harbor and inlet from appropriate State and Federal Agencies.

3. Complete feasibility study for preferred long term alternative. Feasibility study to address:

   - Existing sand budgets in project area
   - Effect on sand budget of proposed nourishment project
   - Required maintenance volumes and cost
   - Need for jetty extension
   - Permitting issues
   - Dredging issues (if applicable)
   - Cost/benefit analysis for beach nourishment and dune restoration

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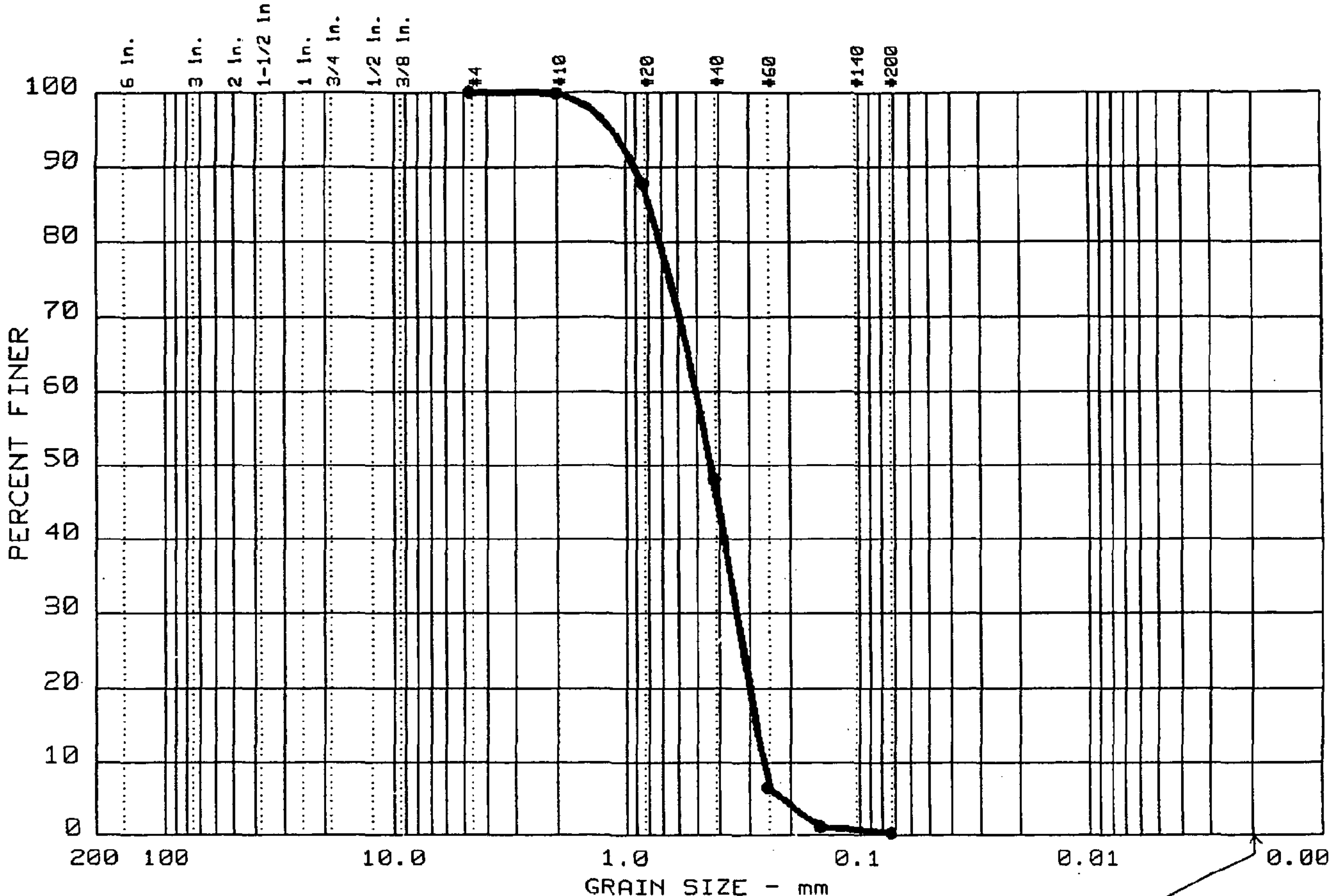
APPENDIX A

GRAIN SIZE DISTRIBUTION TEST REPORT



	Test	% +3"	% GRAVEL	% SAND	% SILT	% CLAY
●	4	0.0	0.0	99.7	0.3	

	LL	PI	D_{85}	D_{60}	D_{50}	D_{30}	D_{15}	D_{10}	C_c	C_u
●			0.79	0.50	0.43	0.335	0.2777	0.2609	0.86	1.9

MATERIAL DESCRIPTION	USCS	AASHTO
● Tan fn/med SAND, trace Silt	SP	A-1-b

Project No.: N951796
Project: APPLEDORE ENGINEERING INC. (AEI #816)
● Location: S-1

Date: May 11, 1995

GRAIN SIZE DISTRIBUTION TEST REPORT

JAWORSKI GEOTECH, INC.

Remarks:
L197-95

Figure No. 1

GRAIN SIZE DISTRIBUTION TEST DATA

Test No.: 4

Date: May 11, 1995
Project No.: N95179G
Project: APPLEDORE ENGINEERING INC. (AEI #816)

Sample Data

Location of Sample: S-1
Sample Description: Tan fn/med SAND, trace Silt
USCS Class: SP
Liquid limit:
AASHTO Class: A-1-b
Plasticity index:

Notes

Remarks: L197-95

Fig. No.: 1

Mechanical Analysis Data

	Initial
Dry sample and tare=	348.59
Tare =	0.00
Dry sample weight =	348.59

Tare for cumulative weight retained= 0

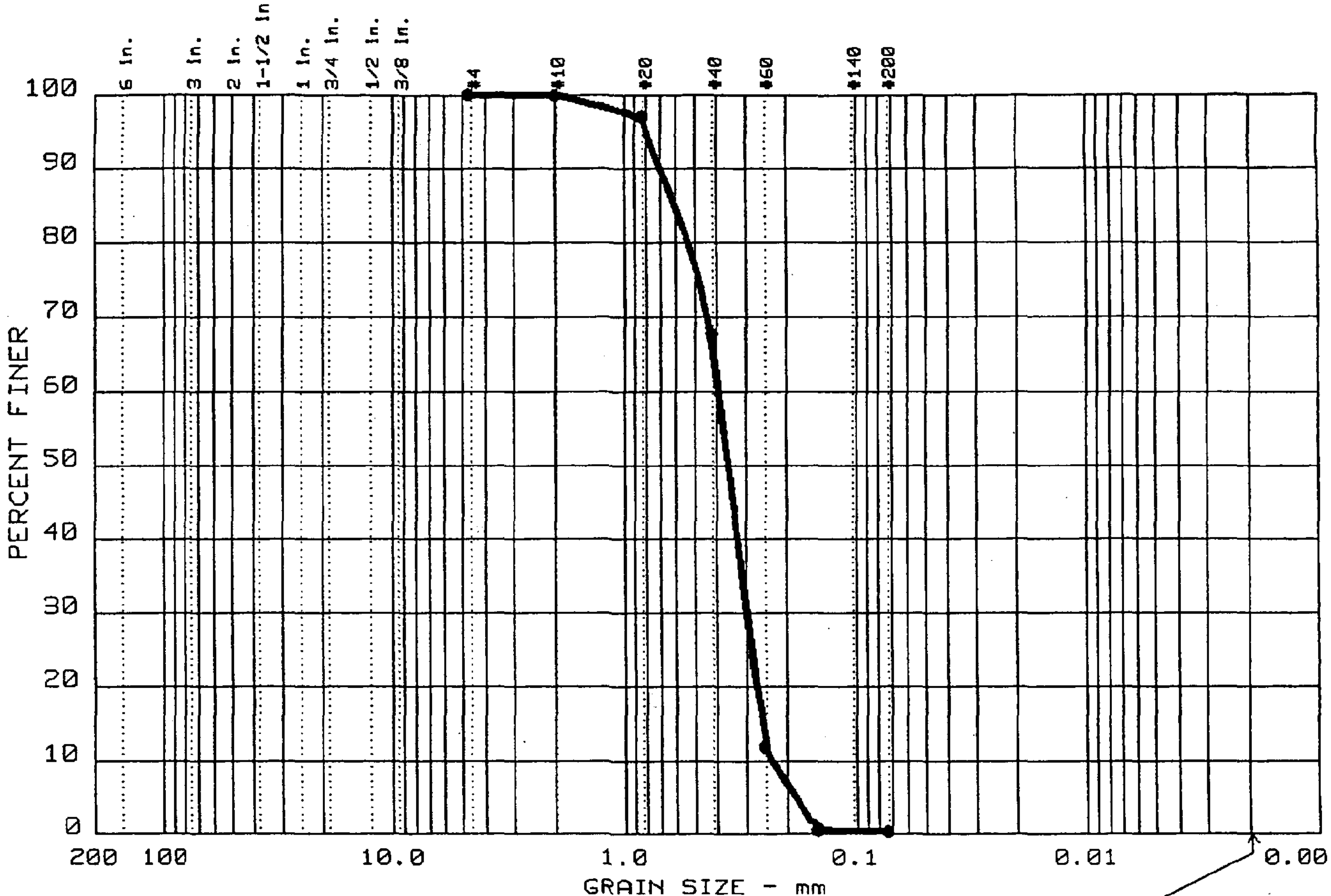
Sieve	Cumul. Wt. retained	Percent finer
# 4	0.00	100.0
# 10	0.65	99.8
# 20	42.42	87.8
# 40	181.05	48.1
# 60	325.72	6.6
# 100	344.83	1.1
# 200	347.65	0.3

Fractional Components

% + 3 in. = 0.0 % GRAVEL = 0.0 % SAND = 99.7
% FINES = 0.3

D85= 0.79 D60= 0.498 D50= 0.431
D30= 0.3346 D15= 0.27765 D10= 0.26092
Cc = 0.8620 Cu = 1.9077

GRAIN SIZE DISTRIBUTION TEST REPORT



	Test	% +3"	% GRAVEL	% SAND	% SILT	% CLAY
●	5	0.0	0.0	99.6	0.4	

	LL	PI	D_{85}	D_{60}	D_{50}	D_{30}	D_{15}	D_{10}	C_c	C_u
●			0.60	0.39	0.36	0.295	0.2570	0.2288	0.98	1.7

MATERIAL DESCRIPTION	USCS	AASHTO
● Tan fn/med SAND, trace Silt	SP	A-3

Project No.: N95179G
Project: APPLEDORE ENGINEERING INC. (AEI #816)
● Location: S-2

Date: May 11, 1995

GRAIN SIZE DISTRIBUTION TEST REPORT

JAWORSKI GEOTECH, INC.

Remarks:

L198-95

Figure No. 1

GRAIN SIZE DISTRIBUTION TEST DATA

Test No.: 5

Date: May 11, 1995
Project No.: N95179G
Project: APPLEDORE ENGINEERING INC. (AEI #816)

Sample Data

Location of Sample: S-2
Sample Description: Tan fn/med SAND, trace Silt
USCS Class: SP
Liquid limit:
AASHTO Class: A-3
Plasticity index:

Notes

Remarks: L198-95

Fig. No.: 1

Mechanical Analysis Data

Initial
Dry sample and tare= 307.00
Tare = 0.00
Dry sample weight = 307.00
Tare for cumulative weight retained= 0

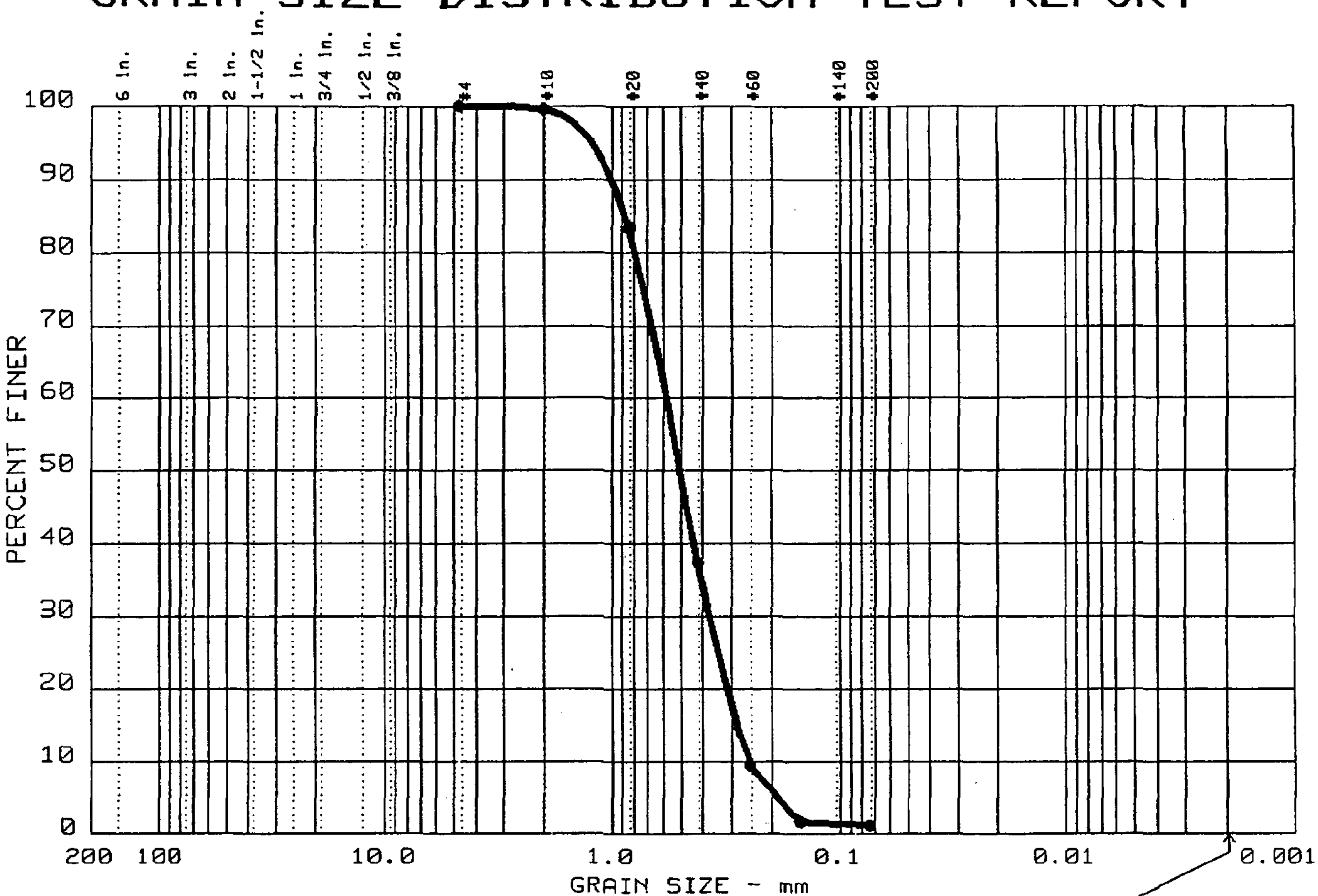
Sieve	Cumul. Wt. retained	Percent finer
# 4	0.00	100.0
# 10	0.14	100.0
# 20	9.04	97.1
# 40	99.21	67.7
# 60	270.37	11.9
# 100	305.33	0.5
# 200	305.92	0.4

Fractional Components

% + 3 in. = 0.0 % GRAVEL = 0.0 % SAND = 99.6
% FINES = 0.4

D85= 0.60 D60= 0.391 D50= 0.356
D30= 0.2955 D15= 0.25704 D10= 0.22882
Cc = 0.9761 Cu = 1.7080

GRAIN SIZE DISTRIBUTION TEST REPORT



	Test	% +3"	% GRAVEL	% SAND	% SILT	% CLAY
●	4	0.0	0.0	98.8	1.2	

	LL	PI	D_{85}	D_{60}	D_{50}	D_{30}	D_{15}	D_{10}	C_c	C_u
●			0.87	0.58	0.50	0.371	0.2815	0.2529	0.95	2.3

MATERIAL DESCRIPTION	USCS	AASHTO
● Tan fn/med SAND, trace Silt	SP	A-1-b

Project No.: N951796
Project: APPLEDORE ENGINEERING INC. (AEI #816)
● Location: S-3

Date: May 11, 1995

GRAIN SIZE DISTRIBUTION TEST REPORT

JAWORSKI GEOTECH, INC.

Remarks:

L199-95

Figure No. 1

GRAIN SIZE DISTRIBUTION TEST DATA

Test No.: 4

Date: May 11, 1995
Project No.: N95179G
Project: APPLEDORE ENGINEERING INC. (AEI #816)

Sample Data

Location of Sample: S-3
Sample Description: Tan fn/med SAND, trace Silt
USCS Class: SP Liquid limit:
AASHTO Class: A-1-b Plasticity index:

Notes

Remarks: L199-95

Fig. No.: 1

Mechanical Analysis Data

Initial
Dry sample and tare= 322.18
Tare = 0.00
Dry sample weight = 322.18
Tare for cumulative weight retained= 0

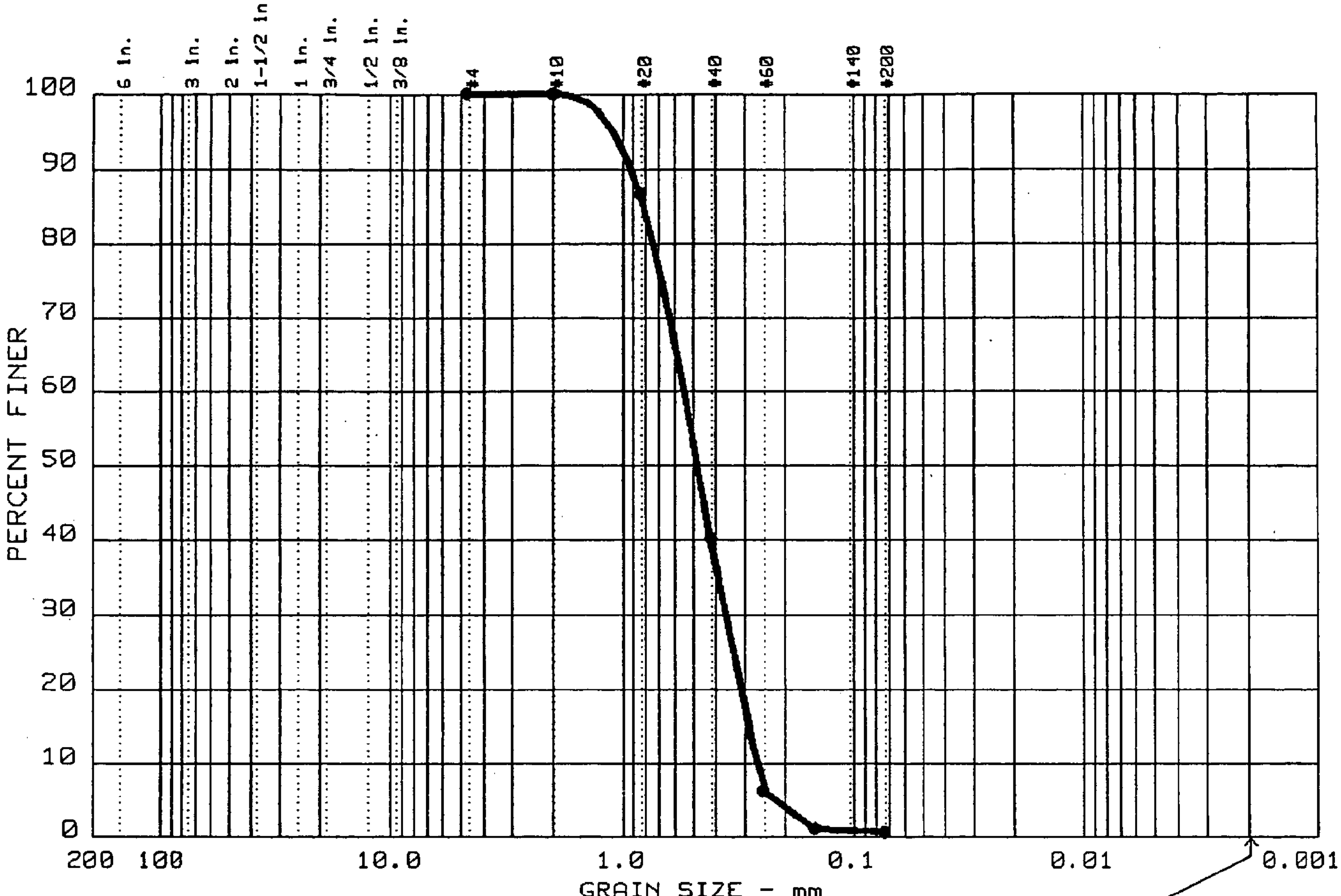
Sieve	Cumul. Wt. retained	Percent finer
# 4	0.00	100.0
# 10	1.40	99.6
# 20	53.73	83.3
# 40	201.91	37.3
# 60	291.55	9.5
# 100	316.78	1.7
# 200	318.34	1.2

Fractional Components

% + 3 in. = 0.0 % GRAVEL = 0.0 % SAND = 98.8
% FINES = 1.2

D85= 0.87 D60= 0.575 D50= 0.501
D30= 0.3711 D15= 0.28151 D10= 0.25293
Cc = 0.9462 Cu = 2.2751

GRAIN SIZE DISTRIBUTION TEST REPORT



	Test	% +3"	% GRAVEL	% SAND	% SILT	% CLAY
●	7	0.0	0.0	99.3	0.7	

	LL	PI	D_{85}	D_{60}	D_{50}	D_{30}	D_{15}	D_{10}	C_c	C_u
●			0.81	0.54	0.48	0.359	0.2851	0.2645	0.90	2.1

MATERIAL DESCRIPTION	USCS	AASHTO
● Tan fn/med SAND, trace Silt	SP	A-1-b

Project No.: N95179G

Project: APPLEDORE ENGINEERING INC. (AEI #816)

● Location: S-4

Date: May 11, 1995

GRAIN SIZE DISTRIBUTION TEST REPORT

JAWORSKI GEOTECH, INC.

Remarks:

L200-95

Figure No. 1

GRAIN SIZE DISTRIBUTION TEST DATA

Test No.: 7

Date:	May 11, 1995
Project No.:	N95179G
Project:	APPLEDORE ENGINEERING INC. (AEI #816)

Sample Data

Location of Sample:	S-4		
Sample Description:	Tan fn/med SAND, trace Silt		
USCS Class:	SP	Liquid limit:	
AASHTO Class:	A-1-b	Plasticity index:	

Notes

Remarks: L200-95

Fig. No.: 1

Mechanical Analysis Data

	Initial
Dry sample and tare=	352.52
Tare =	0.00
Dry sample weight =	352.52

Tare for cumulative weight retained= 0

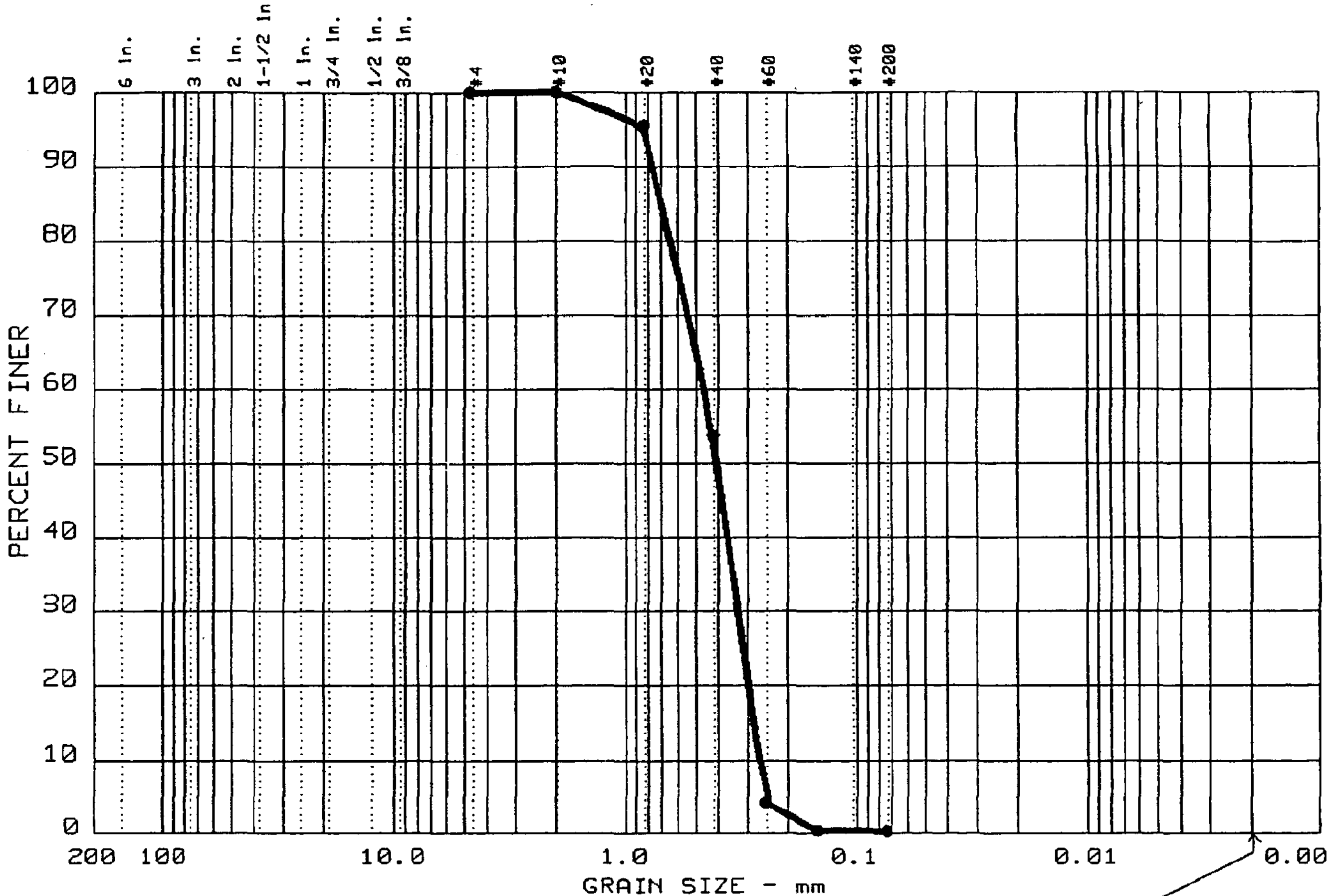
Sieve	Cumul. Wt. retained	Percent finer
# 4	0.00	100.0
# 10	0.06	100.0
# 20	46.89	86.7
# 40	210.52	40.3
# 60	330.60	6.2
# 100	348.69	1.1
# 200	350.02	0.7

Fractional Components

% + 3 in. = 0.0 % GRAVEL = 0.0 % SAND = 99.3
% FINES = 0.7

D85= 0.81 D60= 0.543 D50= 0.475
D30= 0.3589 D15= 0.28510 D10= 0.26455
Cc = 0.8974 Cu = 2.0512

GRAIN SIZE DISTRIBUTION TEST REPORT



	Test	% +3"	% GRAVEL	% SAND	% SILT	% CLAY
●	5	0.0	0.0	99.7	0.3	

	LL	PI	D_{85}	D_{60}	D_{50}	D_{30}	D_{15}	D_{10}	C_c	C_u
●			0.70	0.46	0.40	0.327	0.2796	0.2652	0.88	1.7

MATERIAL DESCRIPTION	USCS	AASHTO
● Tan fn/med SAND, trace Silt	SP	A-3

Project No.: N951796
Project: APPLEDORE ENGINEERING INC. (AEI #816)
● Location: S-5

Date: May 11, 1995

GRAIN SIZE DISTRIBUTION TEST REPORT
JAWORSKI GEOTECH, INC.

Remarks:
L201-95

Figure No. 1

GRAIN SIZE DISTRIBUTION TEST DATA

Test No.: 5

Date: May 11, 1995
Project No.: N95179G
Project: APPLEDORE ENGINEERING INC. (AEI #816)

Sample Data

Location of Sample: S-5
Sample Description: Tan fn/med SAND, trace Silt
USCS Class: SP   Liquid limit:
AASHTO Class: A-3   Plasticity index:

Notes

Remarks: L201-95

Fig. No.: 1

Mechanical Analysis Data

	Initial
Dry sample and tare=	258.51
Tare =	0.00
Dry sample weight =	258.51

Tare for cumulative weight retained= 0

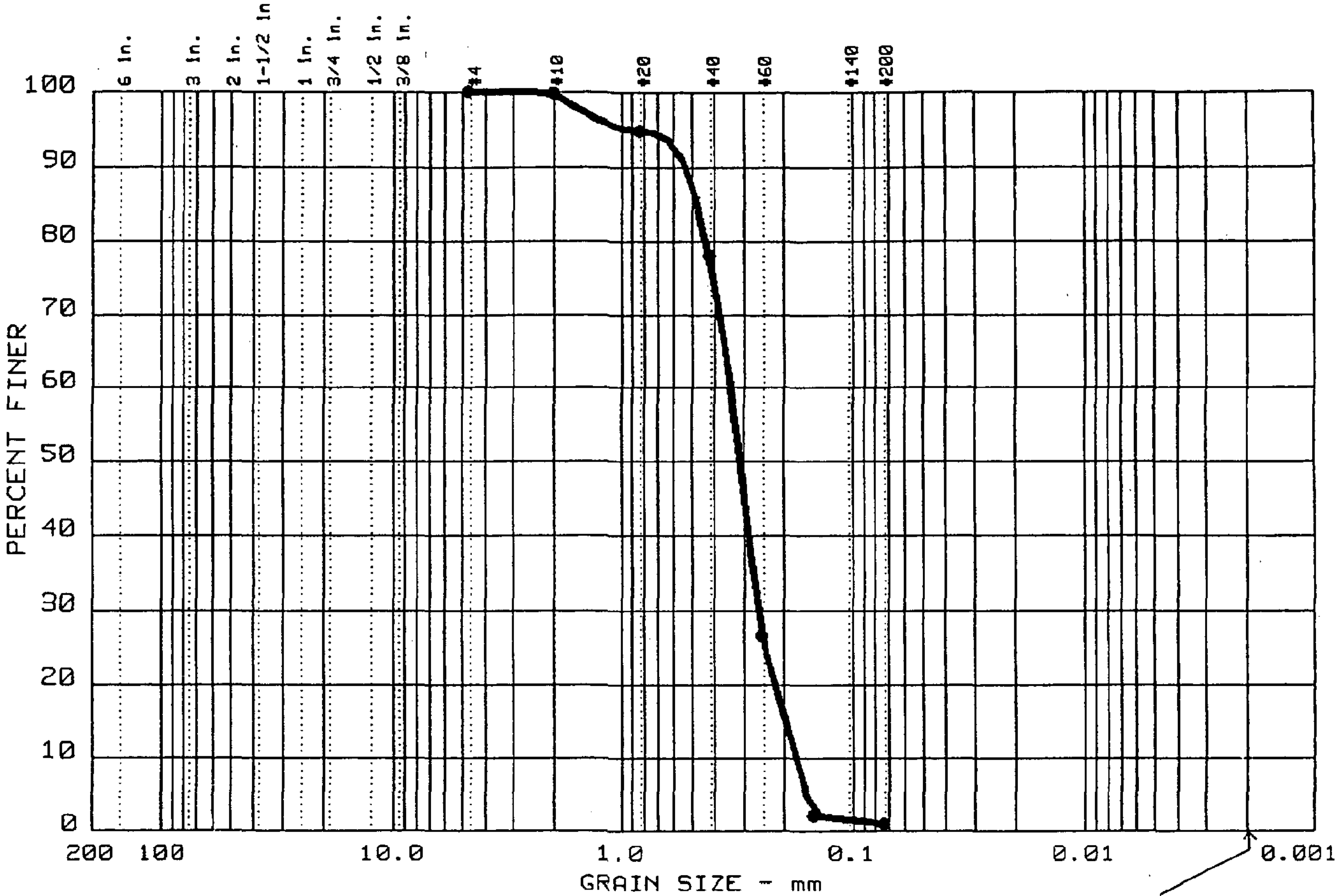
Sieve	Cumul. Wt. retained	Percent finer
# 4	0.00	100.0
# 10	0.01	100.0
# 20	11.81	95.4
# 40	119.48	53.8
# 60	247.41	4.3
# 100	257.48	0.4
# 200	257.70	0.3

Fractional Components

% + 3 in. = 0.0   % GRAVEL = 0.0   % SAND = 99.7
% FINES = 0.3

D85= 0.70 D60= 0.457 D50= 0.404
D30= 0.3270 D15= 0.27958 D10= 0.26516
Cc = 0.8821 Cu = 1.7239

GRAIN SIZE DISTRIBUTION TEST REPORT



	Test	% +3"	% GRAVEL	% SAND	% SILT	% CLAY
●	6	0.0	0.0	99.0	1.0	

	LL	PI	D_{85}	D_{60}	D_{50}	D_{30}	D_{15}	D_{10}	C_c	C_u
●			0.47	0.34	0.31	0.258	0.1954	0.1758	1.12	1.9

MATERIAL DESCRIPTION	USCS	AASHTO
● Grey fn/med SAND, trace Silt	SP	A-3

Project No.: N95179G
Project: APPLEDORE ENGINEERING INC. (AEI #816)
● Location: S-6

Date: May 11, 1995

GRAIN SIZE DISTRIBUTION TEST REPORT
JAWORSKI GEOTECH, INC.

Remarks:
L202-95

Figure No. 1

GRAIN SIZE DISTRIBUTION TEST DATA

Test No.: 6

Date: May 11, 1995
Project No.: N95179G
Project: APPLEDORE ENGINEERING INC. (AEI #816)

Sample Data

Location of Sample: S-6
Sample Description: Grey fn/med SAND, trace Silt
USCS Class: SP   Liquid limit:
AASHTO Class: A-3   Plasticity index:

Notes

Remarks: L202-95

Fig. No.: 1

Mechanical Analysis Data

	Initial
Dry sample and tare=	168.91
Tare =	0.00
Dry sample weight =	168.91

Tare for cumulative weight retained= 0

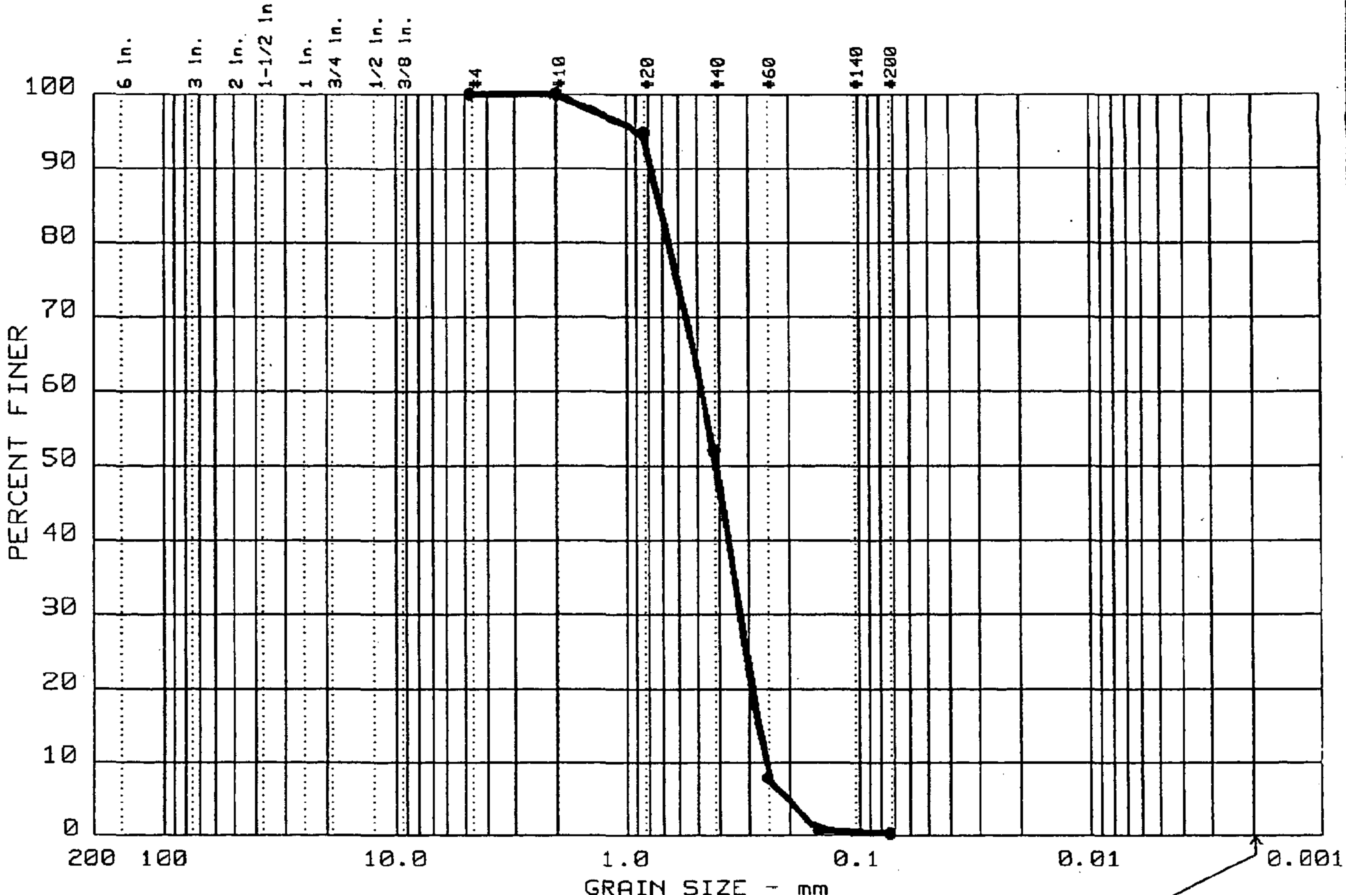
Sieve	Cumul. Wt. retained	Percent finer
# 4	0.00	100.0
# 10	0.34	99.8
# 20	8.72	94.8
# 40	37.00	78.1
# 60	123.89	26.7
# 100	165.35	2.1
# 200	167.22	1.0

Fractional Components

% + 3 in. = 0.0   % GRAVEL = 0.0   % SAND = 99.0
% FINES = 1.0

D85= 0.47 D60= 0.339 D50= 0.309
D30= 0.2579 D15= 0.19543 D10= 0.17579
Cc = 1.1169 Cu = 1.9275

GRAIN SIZE DISTRIBUTION TEST REPORT



	Test	% +3"	% GRAVEL	% SAND	% SILT	% CLAY
●	8	0.0	0.0	99.6	0.4	

	LL	PI	D_{85}	D_{60}	D_{50}	D_{30}	D_{15}	D_{10}	C_c	C_u
●			0.71	0.47	0.41	0.324	0.2716	0.2562	0.87	1.8

MATERIAL DESCRIPTION	USCS	AASHTO
● Tan fn/med SAND, trace Silt	SP	A-3

Project No.: N95179G

Project: APPLEDORE ENGINEERING INC. (AEI #816)

● Location: S-7

Date: May 11, 1995

GRAIN SIZE DISTRIBUTION TEST REPORT

JAWORSKI GEOTECH, INC.

Remarks:

L203-95

Figure No. 1

GRAIN SIZE DISTRIBUTION TEST DATA Test No.: 8

Date: May 11, 1995
Project No.: N95179G
Project: APPLEDORE ENGINEERING INC. (AEI #816)

Sample Data

Location of Sample: S-7
Sample Description: Tan fn/med SAND, trace Silt
USCS Class: SP Liquid limit:
AASHTO Class: A-3 Plasticity index:

Notes

Remarks: L203-95

Fig. No.: 1

Mechanical Analysis Data

	Initial
Dry sample and tare=	217.22
Tare =	0.00
Dry sample weight =	217.22

Tare for cumulative weight retained= 0

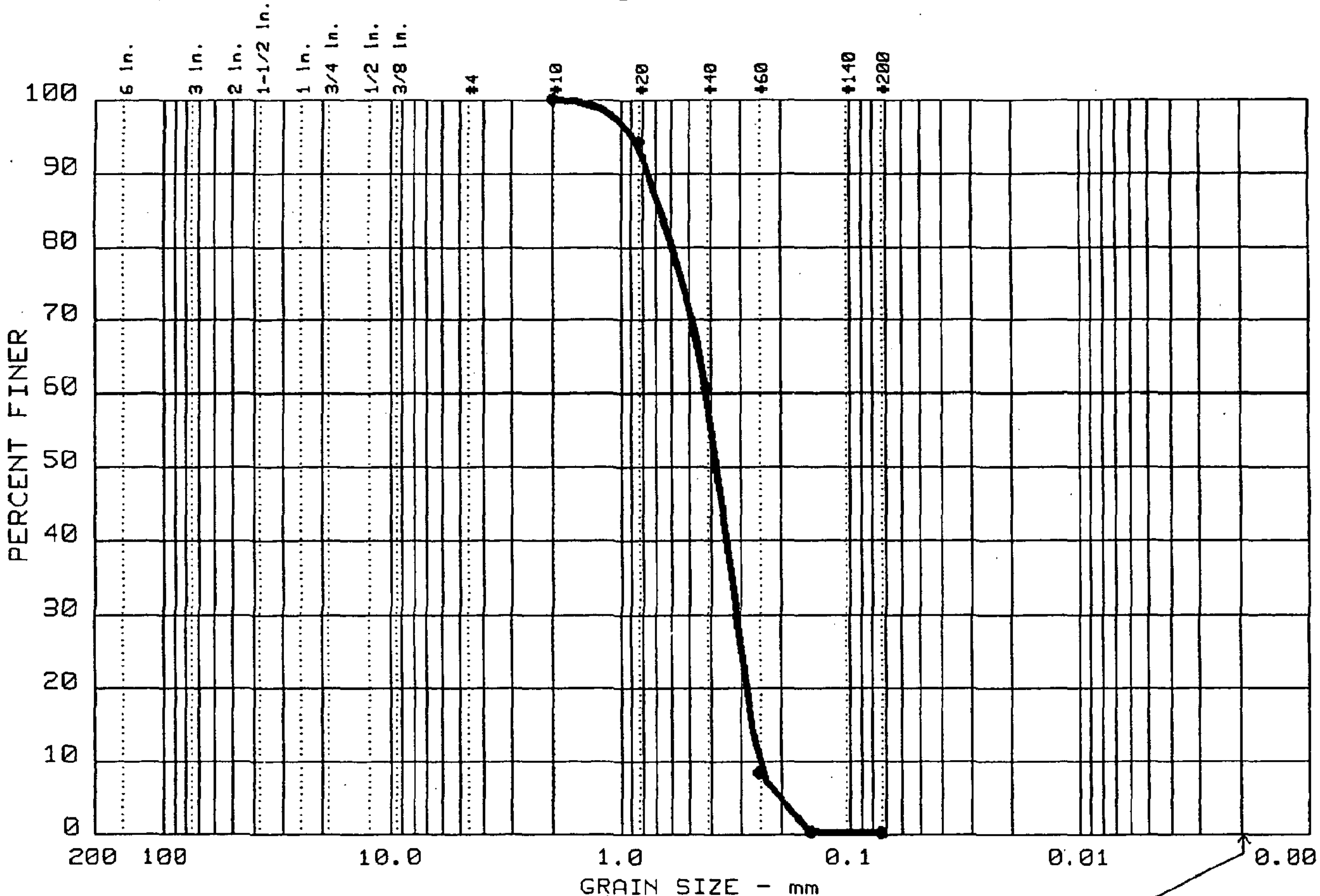
Sieve	Cumul. Wt. retained	Percent finer
# 4	0.00	100.0
# 10	0.01	100.0
# 20	11.26	94.8
# 40	104.26	52.0
# 60	200.06	7.9
# 100	215.57	0.8
# 200	216.45	0.4

Fractional Components

% + 3 in. = 0.0 % GRAVEL = 0.0 % SAND = 99.6
% FINES = 0.4

D85= 0.71 D60= 0.471 D50= 0.410
D30= 0.3240 D15= 0.27164 D10= 0.25615
Cc = 0.8700 Cu = 1.8387

GRAIN SIZE DISTRIBUTION TEST REPORT



	Test	% +3"	% GRAVEL	% SAND	% SILT	% CLAY
●	9	0.0	0.0	99.8	0.2	

	LL	PI	D_{85}	D_{60}	D_{50}	D_{30}	D_{15}	D_{10}	C_c	C_u
●			0.66	0.42	0.38	0.309	0.2664	0.2535	0.91	1.6

MATERIAL DESCRIPTION	USCS	AASHTO
● Tan fn/med SAND, trace Silt	SP	A-3

Project No.: N95179G
Project: APPLEDORE ENGINEERING INC. (AEI #816)
● Location: S-8

Date: May 11, 1995

GRAIN SIZE DISTRIBUTION TEST REPORT

JAWORSKI GEOTECH, INC.

Remarks:

L204-95

Figure No. 1

GRAIN SIZE DISTRIBUTION TEST DATA

Test No.: 9

Date:	May 11, 1995
Project No.:	N95179G
Project:	APPLEDORE ENGINEERING INC. (AEI #816)

Sample Data

Location of Sample:	S-8		
Sample Description:	Tan fn/med SAND, trace Silt		
USCS Class:	SP	Liquid limit:	
AASHTO Class:	A-3	Plasticity index:	

Notes

Remarks: L204-95

Fig. No.: 1

Mechanical Analysis Data

	Initial
Dry sample and tare=	224.38
Tare =	0.00
Dry sample weight =	224.38

Tare for cumulative weight retained= 0

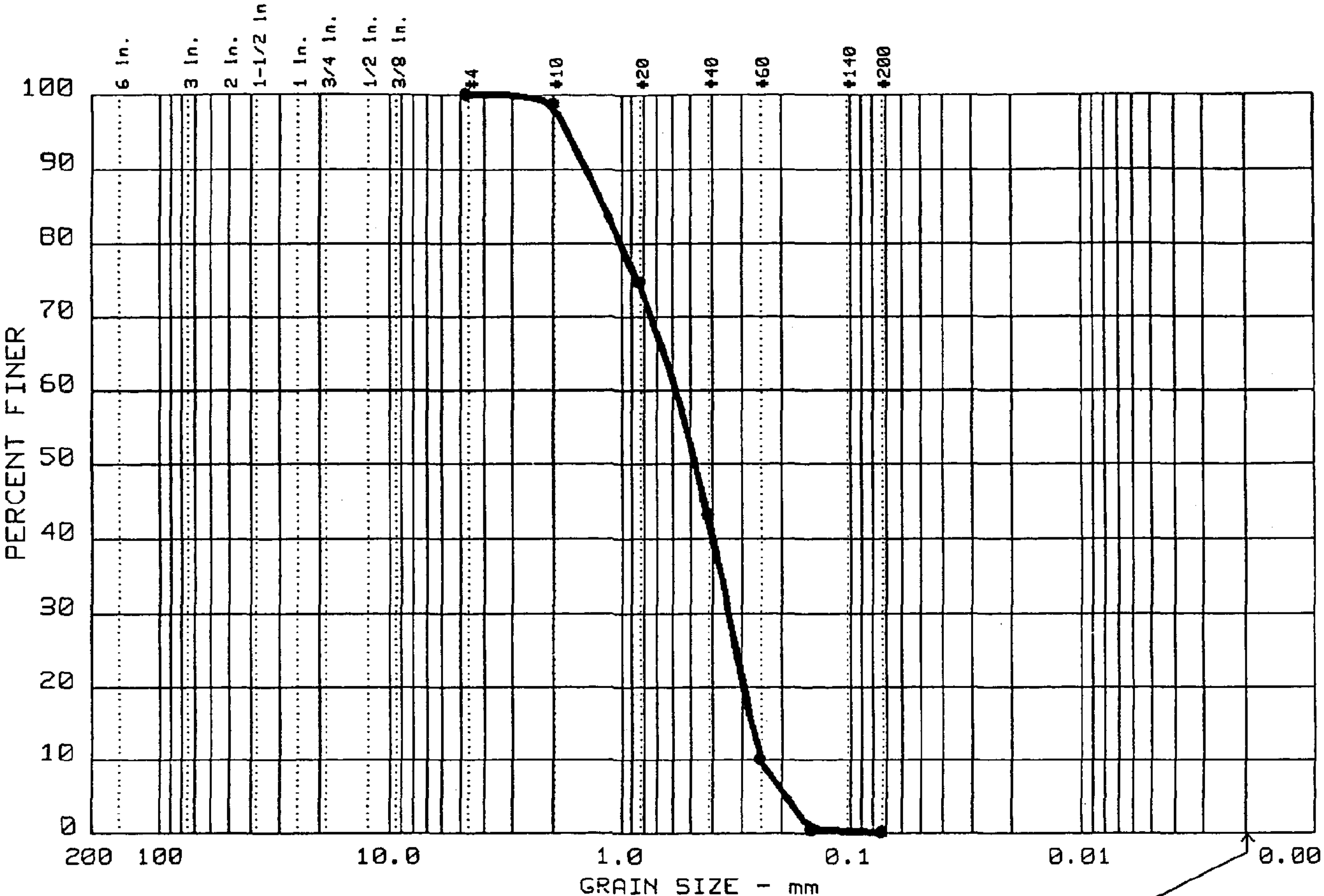
Sieve	Cumul. Wt. retained	Percent finer
# 10	0.00	100.0
# 20	12.84	94.3
# 40	88.48	60.6
# 60	205.27	8.5
# 100	223.62	0.3
# 200	224.01	0.2

Fractional Components

% + 3 in. = 0.0 % GRAVEL = 0.0 % SAND = 99.8
% FINES = 0.2

D85= 0.66 D60= 0.417 D50= 0.378
D30= 0.3094 D15= 0.26638 D10= 0.25351
Cc = 0.9057 Cu = 1.6444

GRAIN SIZE DISTRIBUTION TEST REPORT



	Test	% +3"	% GRAVEL	% SAND	% SILT	% CLAY
●	10	0.0	0.0	99.9	0.1	

	LL	PI	D_{85}	D_{60}	D_{50}	D_{30}	D_{15}	D_{10}	C_c	C_u
●			1.19	0.58	0.47	0.338	0.2707	0.2469	0.80	2.3

MATERIAL DESCRIPTION	USCS	AASHTO
● Tan fn/med SAND, trace Silt	SP	A-1-b

Project No.: N951796
Project: APPLEDORE ENGINEERING INC. (AEI #816)
● Location: S-9

Date: May 11, 1995

GRAIN SIZE DISTRIBUTION TEST REPORT
JAWORSKI GEOTECH, INC.

Remarks:
L205-95

Figure No. 1

GRAIN SIZE DISTRIBUTION TEST DATA

Test No.: 10

Date: May 11, 1995
Project No.: N95179G
Project: APPLEDORE ENGINEERING INC. (AEI #816)

Sample Data

Location of Sample: S-9
Sample Description: Tan fn/med SAND, trace Silt
USCS Class: SP
Liquid limit:
AASHTO Class: A-1-b
Plasticity index:

Notes

Remarks: L205-95

Fig. No.: 1

Mechanical Analysis Data

Initial
Dry sample and tare= 211.17
Tare = 0.00
Dry sample weight = 211.17
Tare for cumulative weight retained= 0

Sieve	Cumul. Wt. retained	Percent finer
# 4	0.00	100.0
# 10	2.73	98.7
# 20	53.31	74.8
# 40	120.04	43.2
# 60	189.85	10.1
# 100	210.09	0.5
# 200	210.97	0.1

Fractional Components

% + 3 in. = 0.0 % GRAVEL = 0.0 % SAND = 99.9
% FINES = 0.1

D85= 1.19 D60= 0.575 D50= 0.471
D30= 0.3381 D15= 0.27071 D10= 0.24689
Cc = 0.8045 Cu = 2.3308

AEI

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